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# **A STUDY OF SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS**

## **Final Briefing Cost Working Group Discussion Session**

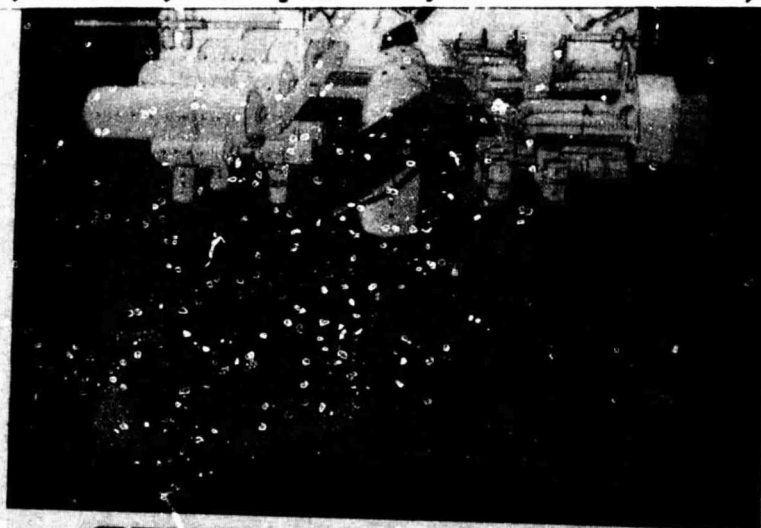


(NASA-CR-173713) A STUDY OF SPACE STATION  
NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS.  
FINAL BRIEFING: COST WORKING GROUP  
DISCUSSION SESSION Final Report (General  
Dynamics/Convair) 60 p HC A04/MF A01

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**GENERAL DYNAMICS**  
*Convair Division*



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# **A STUDY OF SPACE STATION NEEDS, ATTRIBUTES & ARCHITECTURAL OPTIONS**

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## **Final Briefing**

Cost Working Group Discussion Session

National Aeronautics and Space Administration  
George C. Marshall Space Flight Center

18 April 1983

**GENERAL DYNAMICS**

*Convair Division*

## TASK OBJECTIVES & APPROACH

### **Economic benefits**

- Parametric analysis of significant cost elements of alternative approaches & identify cost drivers & sensitivities
  - Research & production
  - Space-based OTV
  - Satellite servicing

### **Programmatic comparisons**

- Generate alternate program costs with a parametric cost model (element level) & a phased funding model
  - Mission payload costs
  - Architectural options
  - Evolutionary options

### **Business opportunity assessment**

- Examine alternate approaches to industry involvement for financing, developing, marketing & operating space station resources
  - Business assessment (Space Station Propectus)
  - Government/industry options (i.e., SDC)

# AGENDA

## **Economic benefits, cost & programmatic analysis (Task 3.3)**

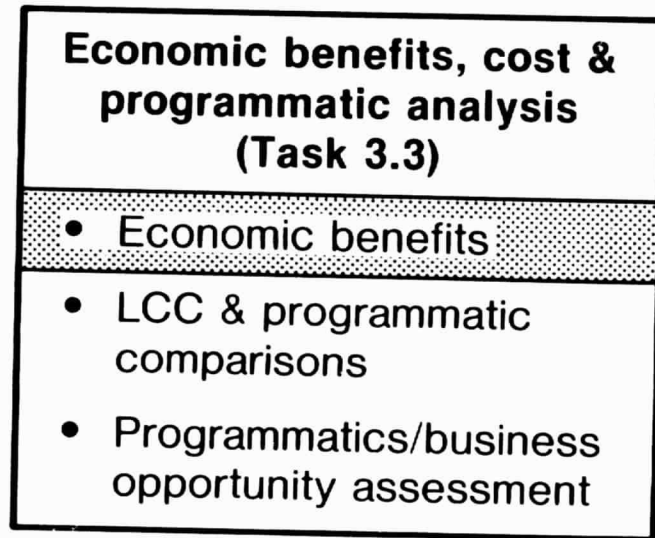
- Economic benefits
- LCC & program comparisons
- Programmatic/business opportunity assessment

◀ M.C. (Mike) Simon

◀ R.E. (Bob) Bradley

◀ M.C. (Mike) Simon

# ECONOMIC BENEFITS STUDIES



**Objective:** Provide an initial assessment of economic benefits (both cost reduction & value added) associated with each of the station's unique functional capabilities

**Approach:** Conduct parametric analyses of significant cost elements of alternate approaches & identify cost drivers & sensitivities

**Tasks:**

- Research & production function
- Satellite servicing & maintenance
- Space-based OTV

## **ECONOMIC BENEFITS SUMMARY**

### **Research & Production**

- Near-term benefits to commercial, science & applications users
- Long-term benefits in materials processing & space industrialization

### **Space-based OTV**

- Significant reduction in cost to GEO
- Benefits to shuttle users
- “ET tanker” concept

### **Satellite servicing**

- Developed servicing benefits model in conjunction with GSFC
- 80% reduction in TMS servicing costs

## ECONOMIC BENEFITS: RESEARCH & PRODUCTION

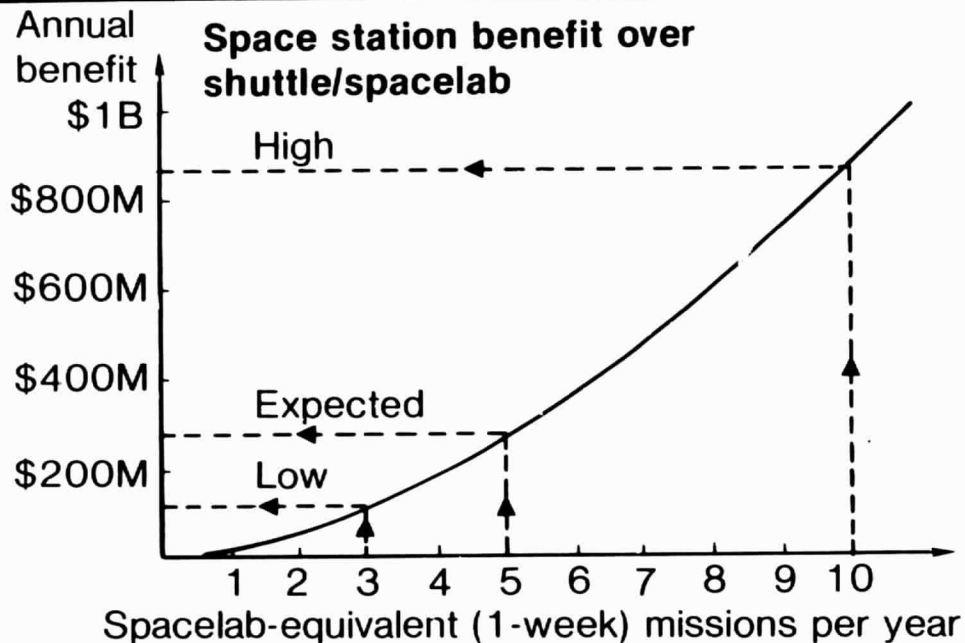
### Cost per kilogram-hour for materials processing in space

\$13,270 — SPAR rocket

\$57 — KC-135 aircraft

\$17 — Space shuttle

\$2 — Space station (90-day production cycle)



### Space station research & production

- Research & production has great long-term potential, but near-term economic benefits are difficult to quantify
- Greatest economic benefits in
  - Materials processing in space
  - Life sciences
  - Astrophysics
- Expected annual benefit
  - 1990-2000: \$285 million
  - 2000+: Potentially very large
- Evolution to permanent industrial base in space, utilizing non-terrestrial sources for raw materials

# RESEARCH & PRODUCTION BENEFITS ANALYSIS (1984\$)

	Cost/kg-hr for Materials Processing in Space					
	Mission Capability		Cost			
	Hours	Kg	Transportation	House-keeping	Total	Cost/kg-hr
SPAR Rocket	0.083	454	500,000	N/A	500,000	13,270
KC-135 Aircraft	0.014	7,600	6,000	N/A	6,000	56.80
Space Shuttle	168	19,500	83.3M	N/A	83.3M	16.80
Space Station (90-day)	2,160	14,125	53.1M	9M	62.1M	2.04
Space Station (2-year)	17,520	14,125	127.4M	73M	200.4M	.81

	Cost/kg-hr for Upper Atmosphere Research					
	Mission Capability		Cost			
	Hours	Kg	Transportation	House-keeping	Total	Cost/kg-hr
Space Shuttle	168	25,500	12.1M	N/A	12.1M	23.81
Space Station (90-day)	2,160	25,500	12.1M	4.5M	16.6M	3.07
Space Station (2-year)	17,520	2,500	12.1M	36.5M	48.6M	1.11

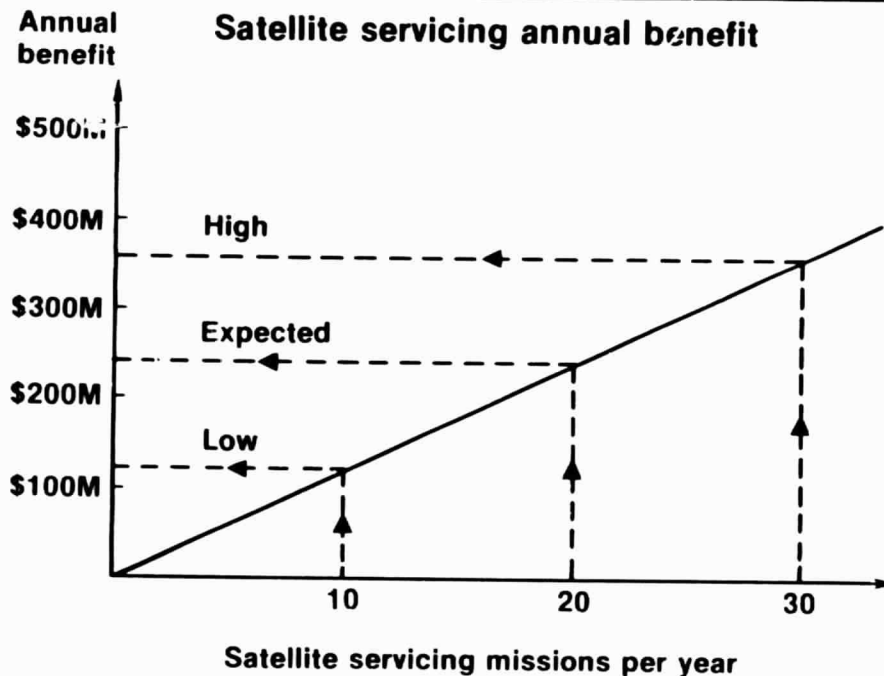
	Spacelab Accommodation Cost Comparison			
	Transportation	P/L integration	Housekeeping	Total
Space Shuttle	83.3M	16.7M	N/A	100M
Space Station	36.7M	25.0M	1.4M	63.1M

# ECONOMIC BENEFITS: SATELLITE SERVICING

## Average satellite servicing cost/value (per mission)\*

\$18.2M	— Cost of servicing from space shuttle
\$17.6M	— Value of satellite servicing
\$4.9M	— Cost of servicing from space station

\*Using TMS & unmanned servicing module



## Space Station Satellite Servicing

- Satellite servicing from space station expected to cost 75% less than servicing from space shuttle
- Results of satellite servicing (per mission, average)
  - From shuttle: \$600,000 loss
  - From space station: \$12 million benefit
- Expected annual benefit: \$240 million
- Significant parameters
  - Satellite capabilities restored by servicing
  - Value of satellite
  - Satellite servicing mission model

## **SATELLITE SERVICING BENEFITS**

Net benefit per mission:  $b = [m \times (e/d) \times (l + u)] - c$

Where:

m = Mission criticality factor

e = Life extension factor

d = Design life

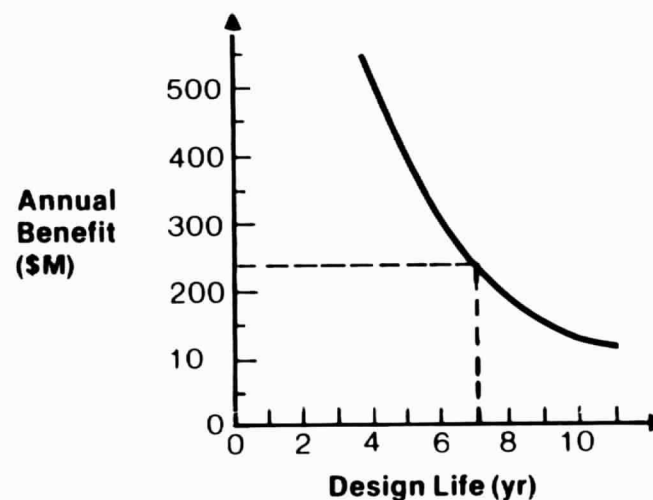
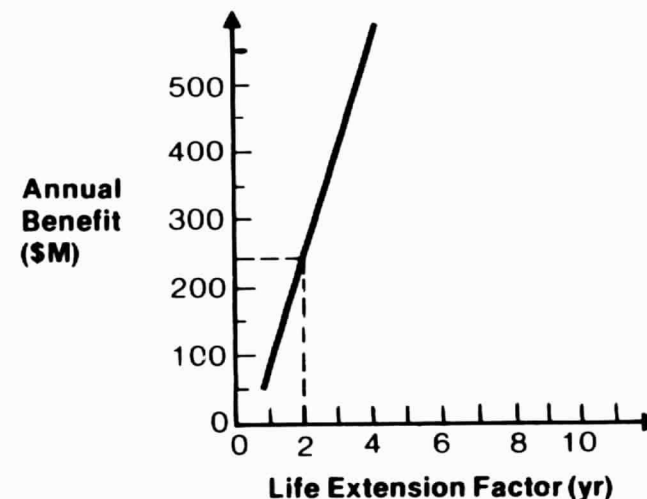
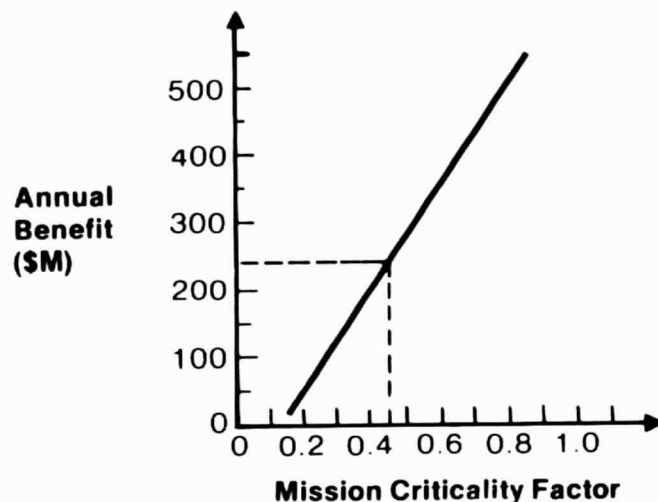
l = Launch cost

u = Unit cost

c = Cost of servicing mission

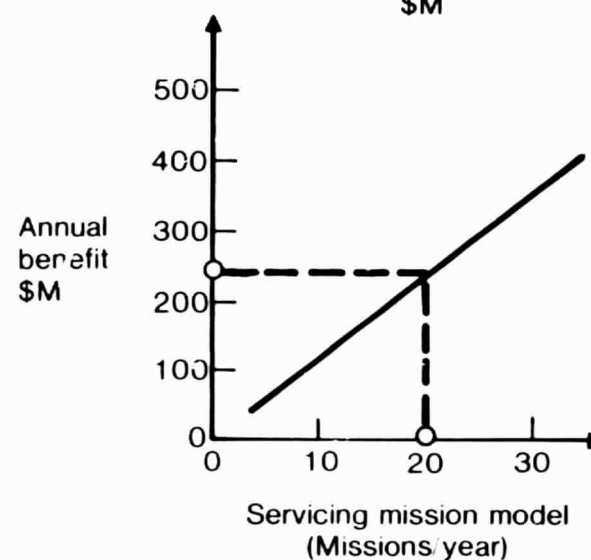
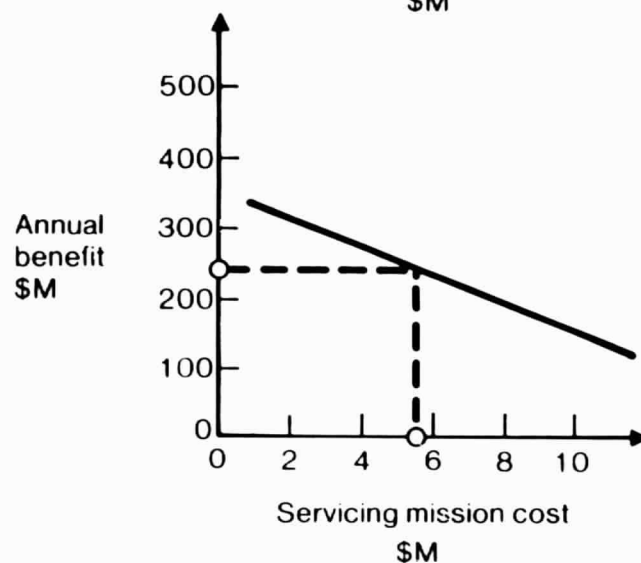
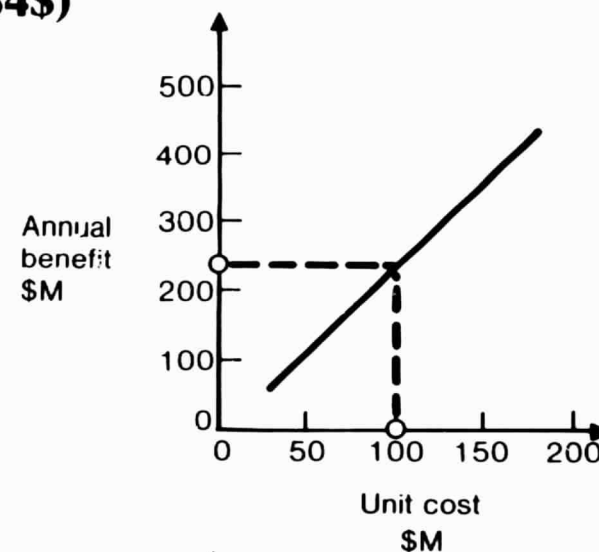
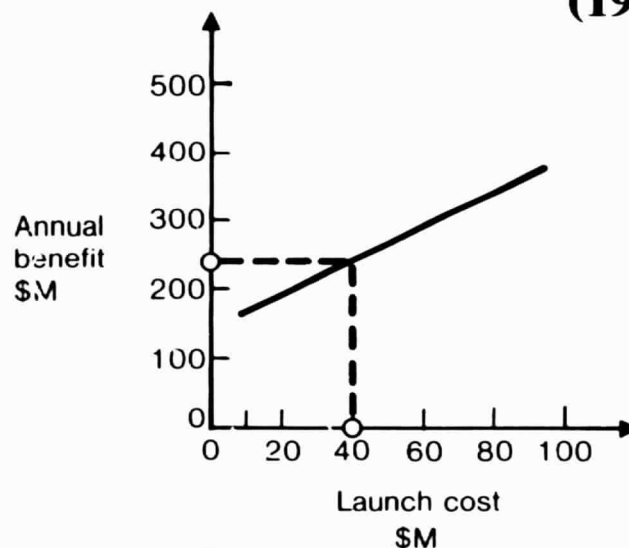
**Preliminary result: b = \$10-20 million**

## SATELLITE SERVICING SENSITIVITY ANALYSIS: MISSION CRITICALITY & SATELLITE LIFETIME FACTORS (1984\$)



# SATELLITE SERVICING SENSITIVITY ANALYSIS: COST & MISSION MODEL FACTORS

(1984\$)



SPACE STATION ECONOMIC BENEFITS  
SATELLITE SERVICING SENSITIVITY ANALYSIS  
(1984 \$)

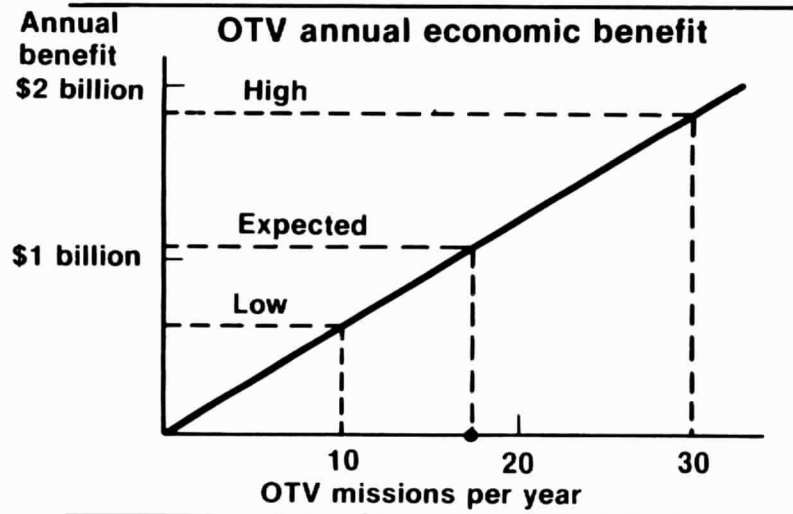
**GENERAL DYNAMICS**  
*Convair Division*

Variable	Low Value	High Value	Expected Value	Worst-Case Benefit	Best-Case Benefit	Sensitivity
Mission criticality factor	.2	.6	.44	\$ 48M	\$368M	High
Life extension factor	1	4	2	\$ 64M	\$592M	High
Design life	3	10	7	\$134M	\$709M	High
Launch cost	\$25M	\$ 75M	\$ 40M	\$202M	\$328M	Moderate
Unit cost	\$50M	\$150M	\$100M	\$114M	\$366M	High
Cost of servicing mission	\$ 3M	\$ 10M	\$5-6M	\$152M	\$292M	Moderate
Number of servicing missions/yr	10	30	20	\$120M	\$360M	High

# ECONOMIC BENEFITS: SPACE-BASED OTV

## Cost-per-pound to geosynchronous orbit

\$17,000/lb	PAM-D
\$21,000/lb	PAM-DII
\$21,000/lb	PAM-A
\$30,000/lb	IUS
\$9,000/lb	Shuttle/Centaur
\$13,000/lb	Shuttle-based OTV
\$6,000/lb	Space-based OTV



## Space-based OTV

- Greatest quantifiable economic benefit of space station program
- Expected annual benefit of over \$1 billion
- Maximizes efficiency of space transportation system
- Significant parameters
  - Shuttle payload delivery cost to LEO
  - Propellant delivery cost to LEO
  - OTV mission model
  - Competitor cost
- Benefits generally insensitive to
  - OTV production costs
  - OTV operations costs (ground & space)
  - OTV spares/refurbishing costs

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## OTV ECONOMIC BENEFITS ANALYSIS (1984 \$)

Cost Factor (per 10,000 lb of payload)	Mission Cost	
	OTV	Competitor Average*
Upper stage cost	\$ 0.5M	\$ 17.0M
Upper stage delivery to LEO	\$ 0.5M	\$108.5M
Payload delivery to LEO	\$45.4M	0
Operations/spares costs	\$ 3.0M	0
Propellant delivery to LEO	\$13.5M	0
} OTV only		
Total	\$62.9M	\$125.5M

\*PAM-D, PAM-D II, Leasat, PAM-A, Atlas/Centaur, Shuttle/Centaur, TOS, shuttle-based OTV

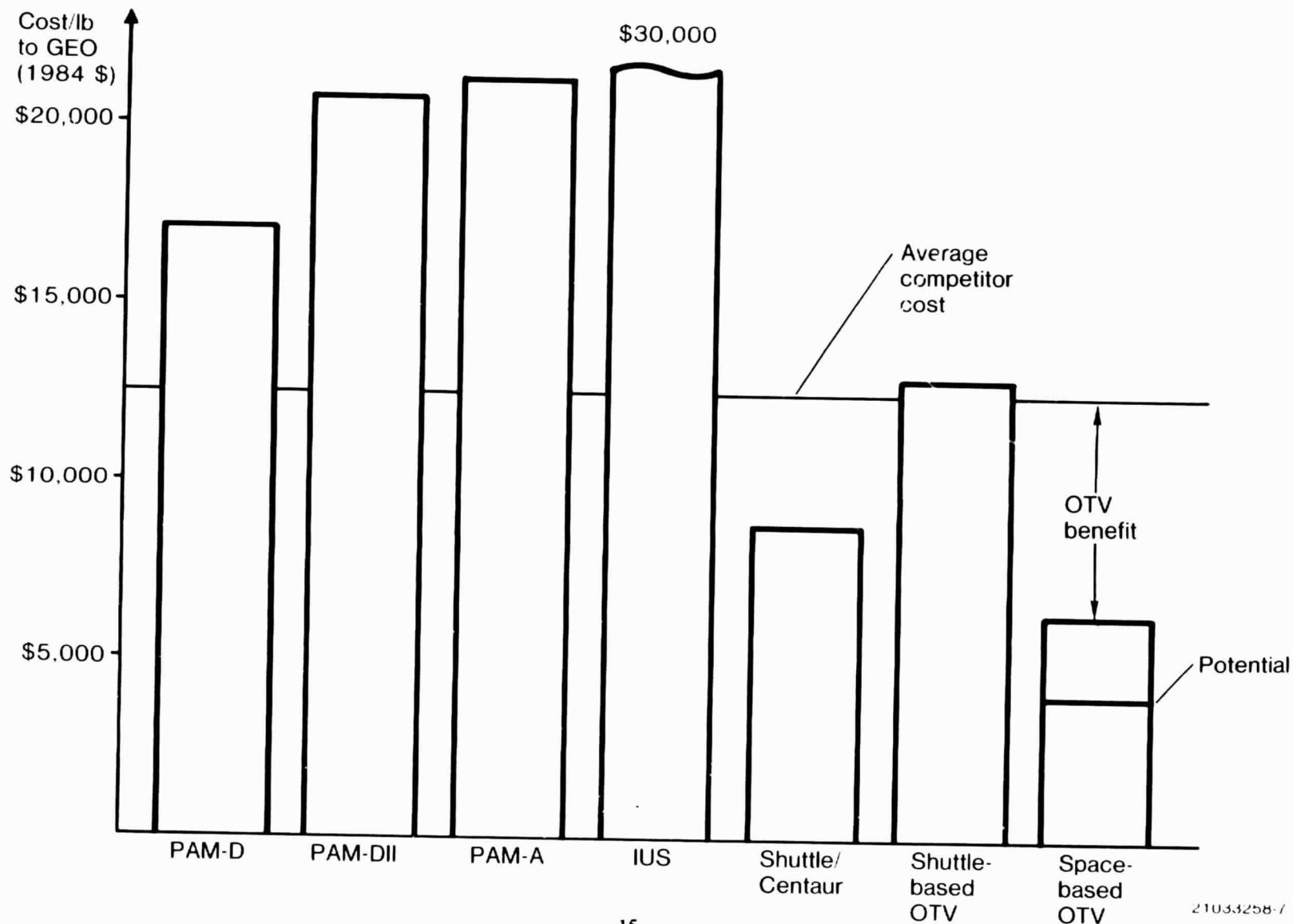
Economic benefit per OTV mission = \$125.5M - \$62.9M = \$62.6M

Average number of OTV missions per year (1994-2000) = .75 × 23 = 17.3

**OTV economic benefit per year = \$62.6M × 17.3 = \$1.08 billion**

# UPPER-STAGE TRANSPORTATION COST (1984 \$/LB TO GEO)

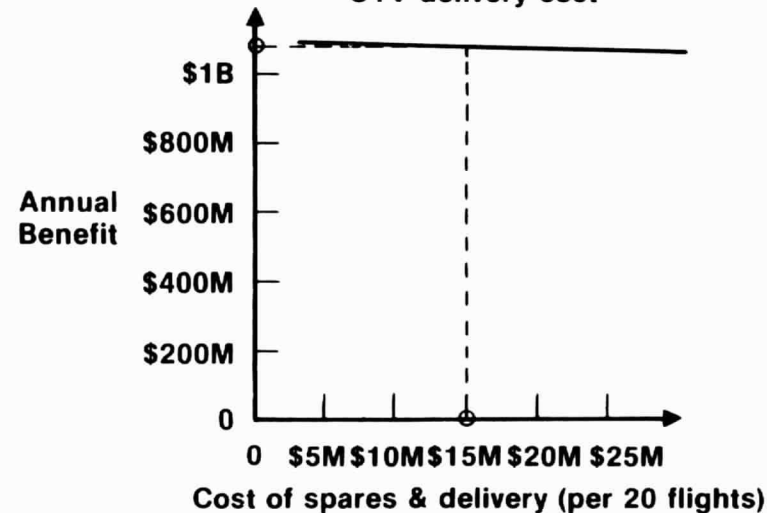
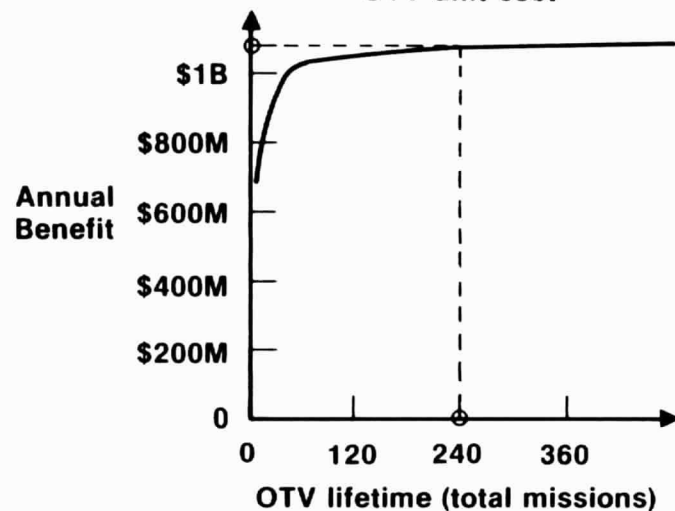
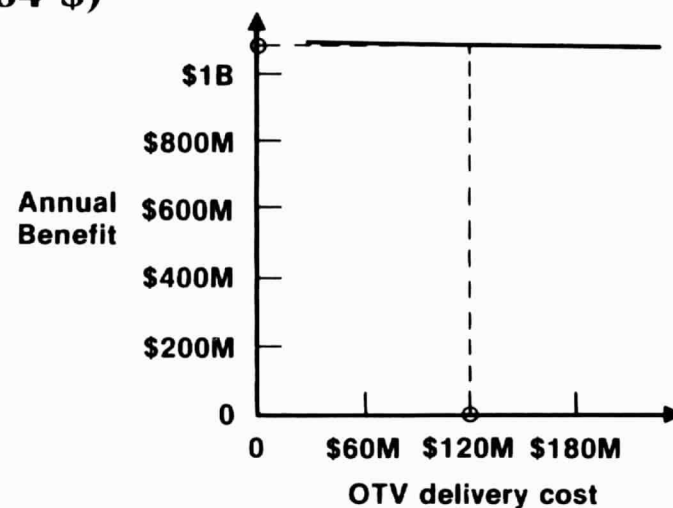
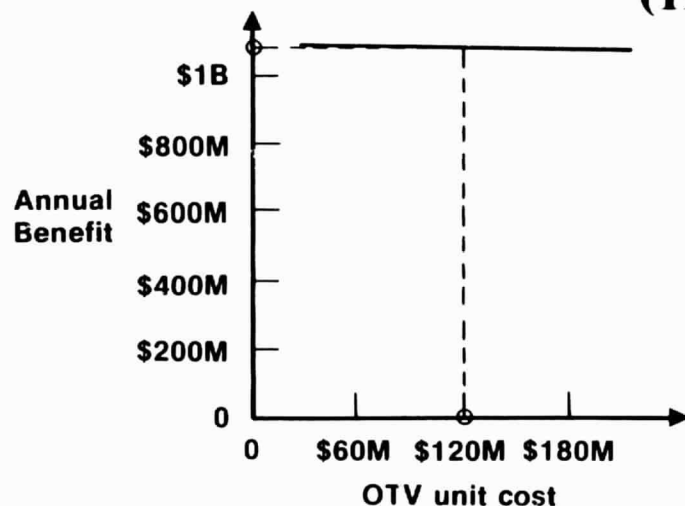
GENERAL DYNAMICS  
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# SATELLITE LAUNCH COST COMPARISON (1984 \$)

Satellite	Lower Stage	Shuttle/ Lower Stage Cost	Upper Stage	Upper Stage Cost	Total Cost to GEO
TDRS	Shuttle	\$ 90M	IUS	\$ 55M	\$ 145M
INTELSAT VI	Shuttle	55M	IUS 1st stage	15M	70M
INTELSAT V-A	Atlas	55M	Centaur	Included	55M
Hughes Leasat	Shuttle	28M	Unique	Included	28M
Hughes 376	Shuttle	17M	PAM-D	6M	23M
Modified 376	Shuttle	9M	OTV	4M	13M
SX	Shuttle	6M	OTV	4M	10M

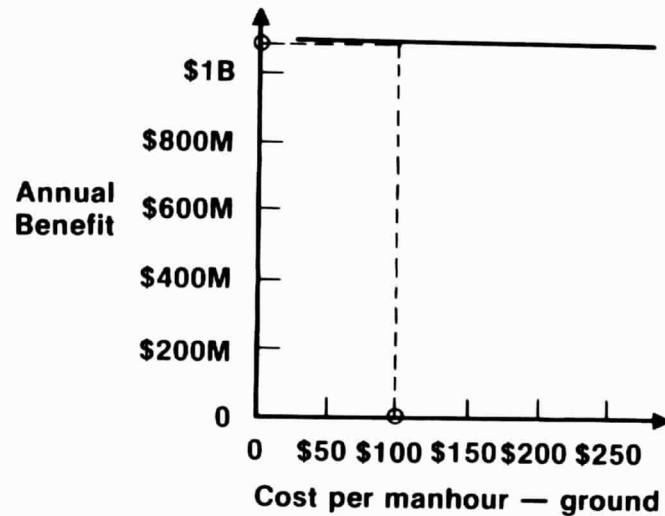
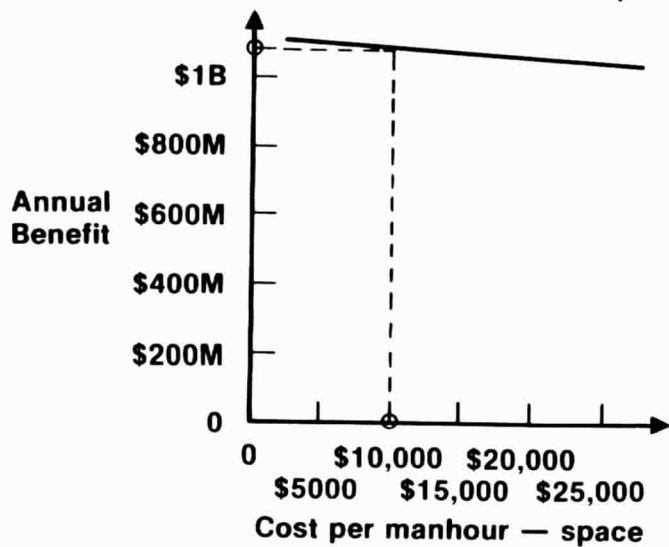
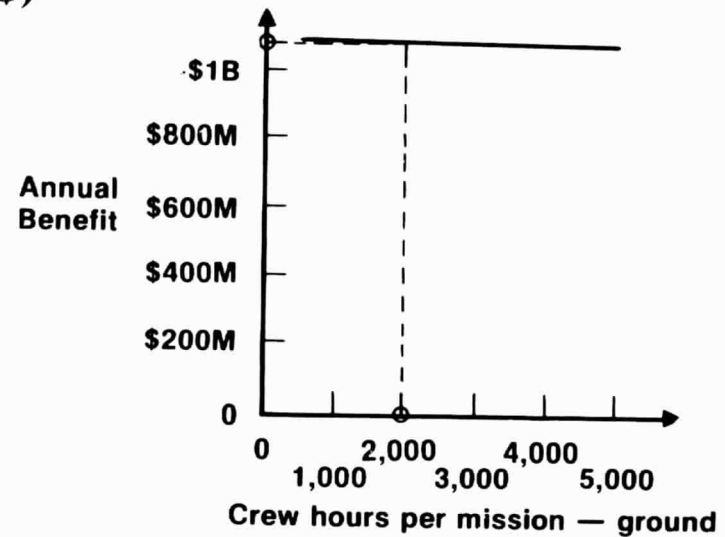
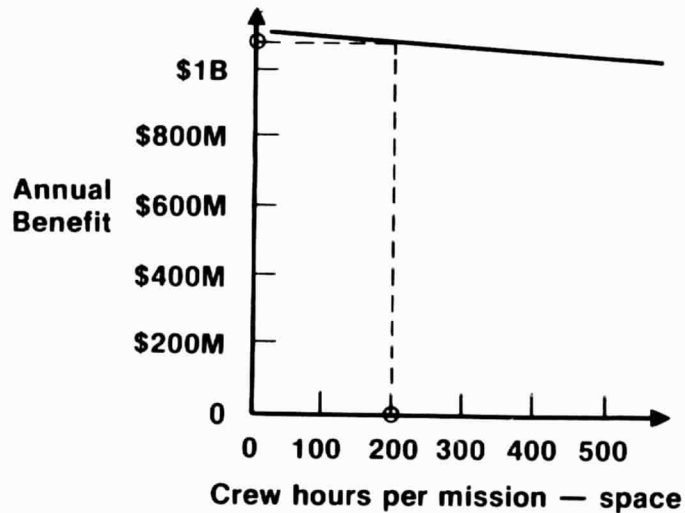
# OTV SENSITIVITY ANALYSIS: VEHICLE PRODUCTION AND MAINTENANCE COSTS (1984 \$)



Conclusion: OTV economic benefits have extremely low sensitivity to vehicle production & maintenance costs

# OTV SENSITIVITY ANALYSIS: CREW OPERATIONS COSTS (1984 \$)

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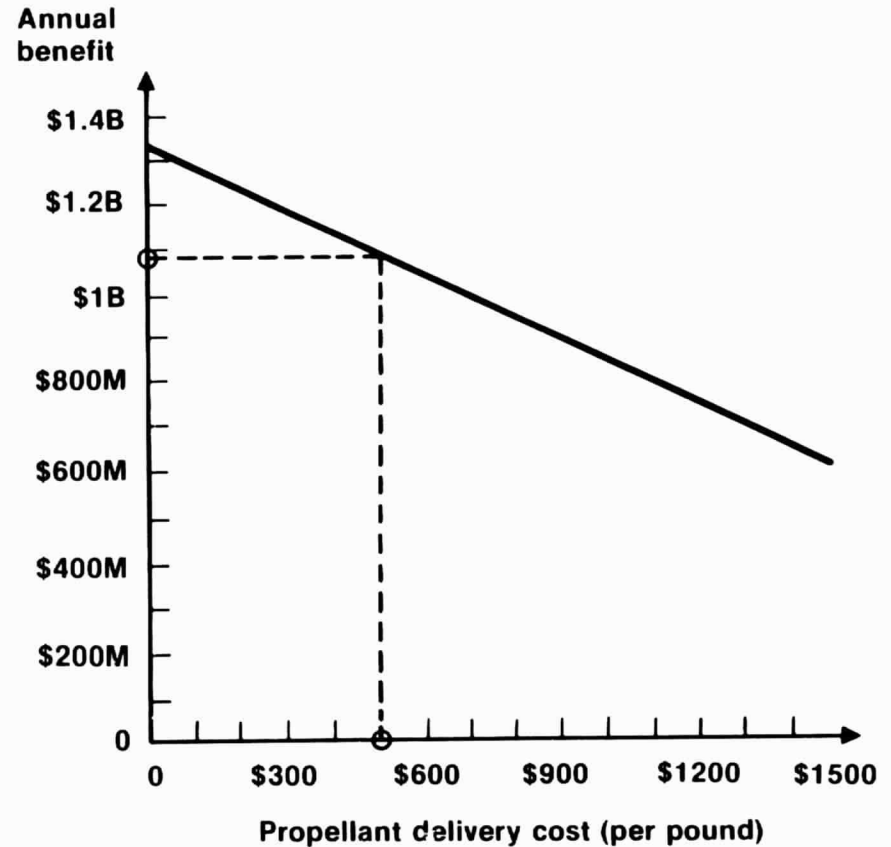
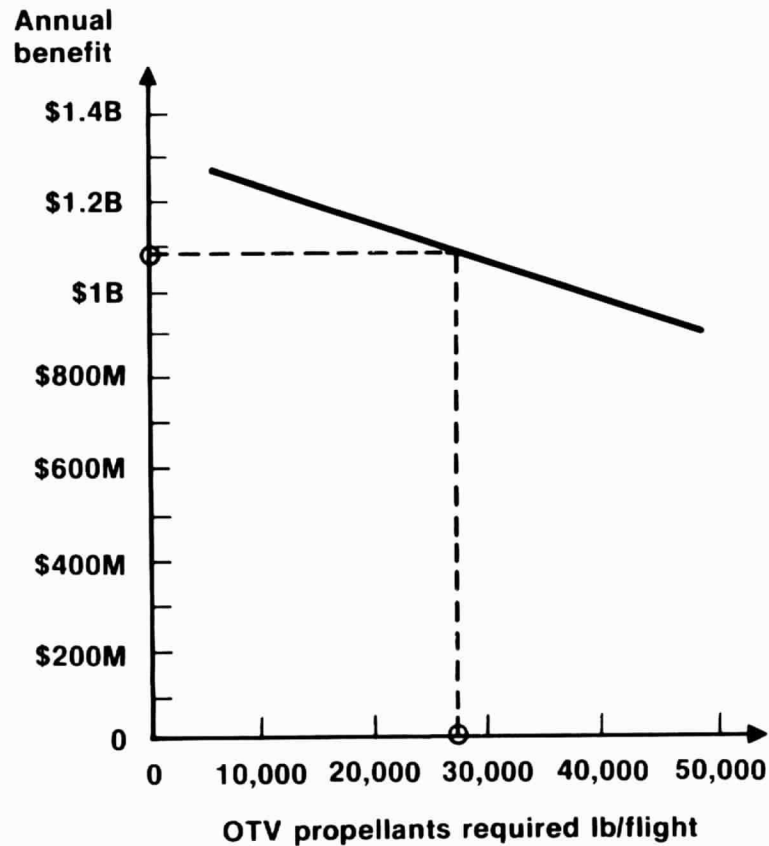


Conclusion: OTV economic benefits have low sensitivity to crew operations costs

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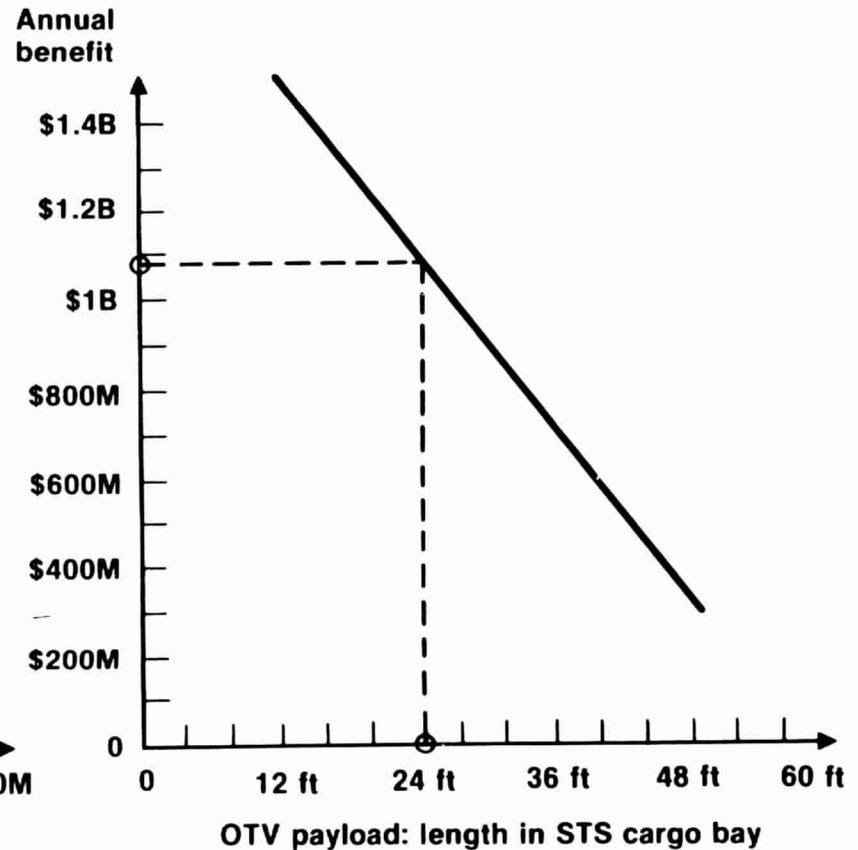
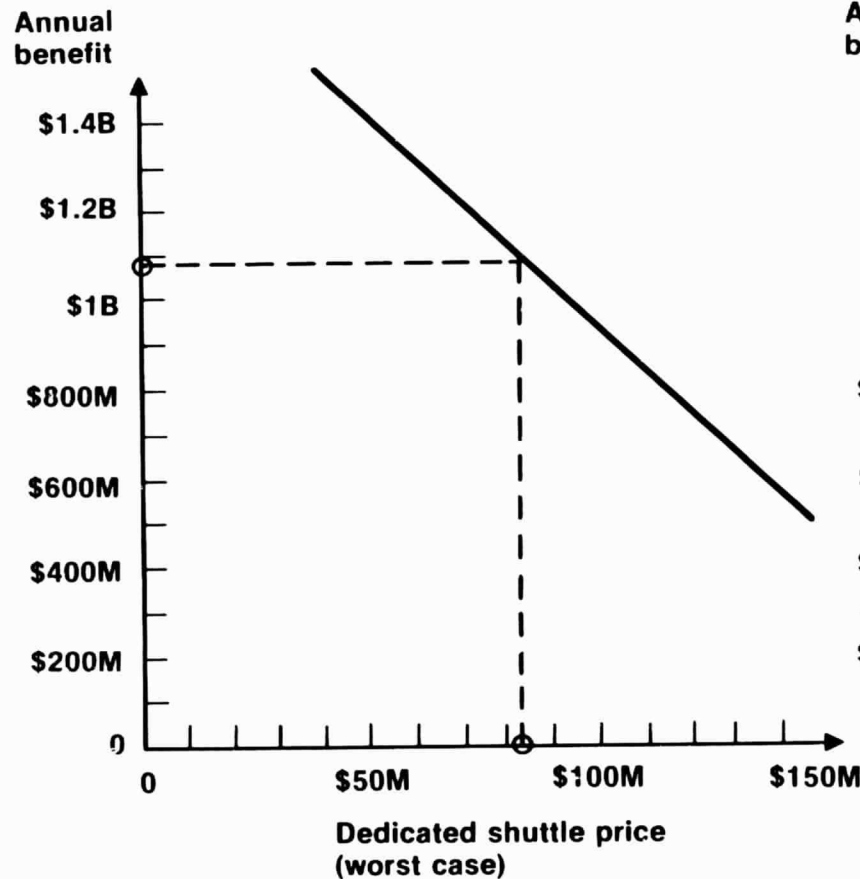
# OTV SENSITIVITY ANALYSIS: PROPELLANT REQUIREMENTS & COSTS (1984 \$)

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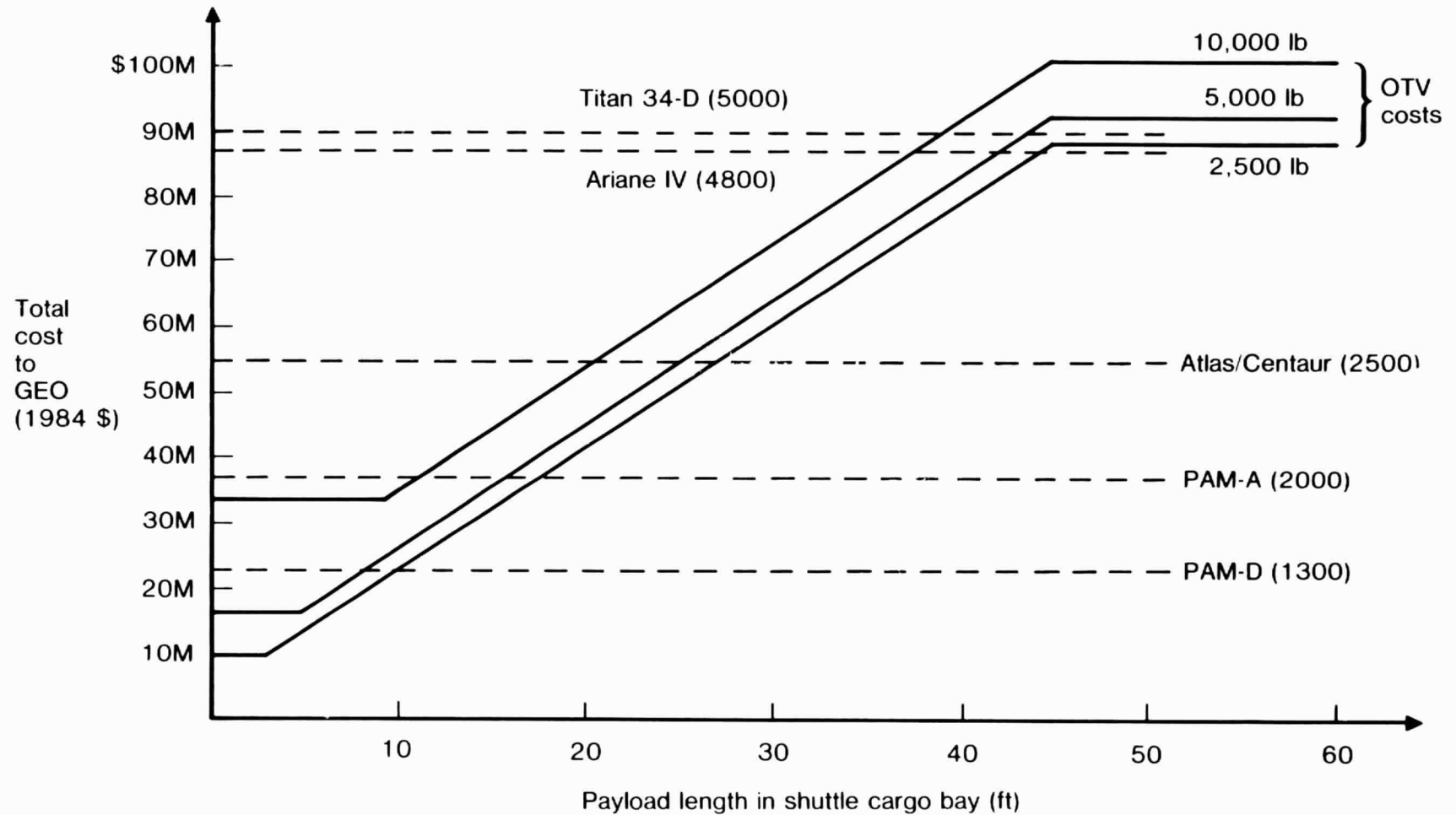
**Conclusion: OTV economic benefits have moderate sensitivity to propellant requirements & costs**

# OTV SENSITIVITY ANALYSIS: SHUTTLE-RELATED COSTS (1984 \$)



**Conclusion:** OTV economic benefits have low sensitivity to shuttle price & high sensitivity to cargo by length utilized for delivery of OTV payloads to LEO

## COST TO GEO AS A FUNCTION OF PAYLOAD LENGTH



# SPACE STATION ECONOMIC BENEFITS: OTV SENSITIVITY ANALYSIS (1984 \$)

**GENERAL DYNAMICS**  
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Variable	Low Value	High Value	Assumed Value	OTV Annual Benefit		
				Worst Case	Best Case	Sensitivity
OTV unit cost	\$60M	\$180M	\$120M	\$1.08B	\$1.09B	Low
OTV delivery cost	\$60M	\$180M	\$120M	\$1.08B	\$1.09B	Low
OTV lifetime (flights)	60	480	240	\$1.03B	\$1.09B	Low
Spares cost (per 20 flights)	\$10M	\$30M	\$15M	\$1.07B	\$1.09B	Low
Crew hours per mission — space	50	500	200	\$1.03B	\$1.11B	Low
Crew hours per mission — ground	500	5000	2000	\$1.08B	\$1.09B	Low
Cost of crew time — space	\$5,000/hr	\$25,000/hr	\$10,000/hr	\$1.03B	\$1.10B	Low
Cost of crew time — ground	\$50/hr	\$250/hr	\$100/hr	\$1.08B	\$1.09B	Low
Propellants required — per mission	20,000/lb	35,000/lb	27,000/lb	\$1.02B	\$1.15B	Low
Propellants cost	\$250/lb	\$1500/lb	\$500/lb	\$618M	\$1.20B	High
Shuttle: dedicated price	\$70M	\$100M	\$83.3M	\$927M	\$1.21B	Low
Shuttle: payload length (average)	12 ft	40 ft	24.5 ft	\$588M	\$1.48B	High
Competitor cost per mission	\$75M	\$200M	\$125.5M	\$211M	\$2.37B	High
OTV missions per year (average)	10	25	17.3*	\$627M	\$1.57B	High

\* Assumes 75% market share of 23 OTV-equivalent missions per year

# IMPACT OF OTV ON SHUTTLE UTILIZATION AND COSTS

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SHUTTLE LOAD FACTORS FOR 10,000-LB DELIVERY TO GEOSYNCHRONOUS ORBIT		
ELVs	SHUTTLE UPPER-STAGES	SPACE-BASED OTV
0	PAM-D 1.09 TOS 1.00 SHUTTLE-BASED OTV (REUSABLE) 1.32 SHUTTLE-CENTAUR 0.71	0.41
AVERAGE: 0	AVERAGE: 1.03	

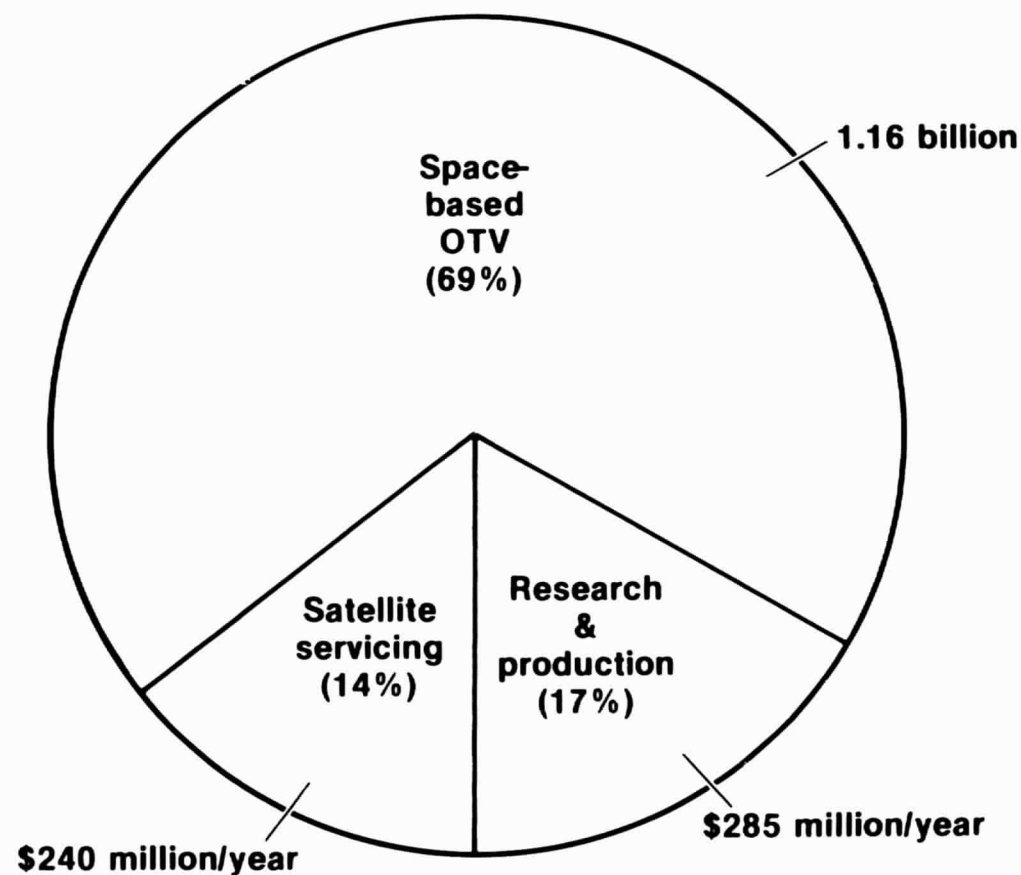
WITHOUT OTV: 3/4 SHUTTLE, 1/4 ELVs - AVERAGE LOAD FACTOR = 0.77

WITH OTV: 3/4 OTV, 1/8 SHUTTLE, 1/8 ELVs - AVERAGE LOAD FACTOR = 0.44

OTV REDUCTION IN SHUTTLE UTILIZATION: (PER OTV MISSION) 0.33  
(ANNUAL) 5.71 (17.3 MISSIONS/YEAR)

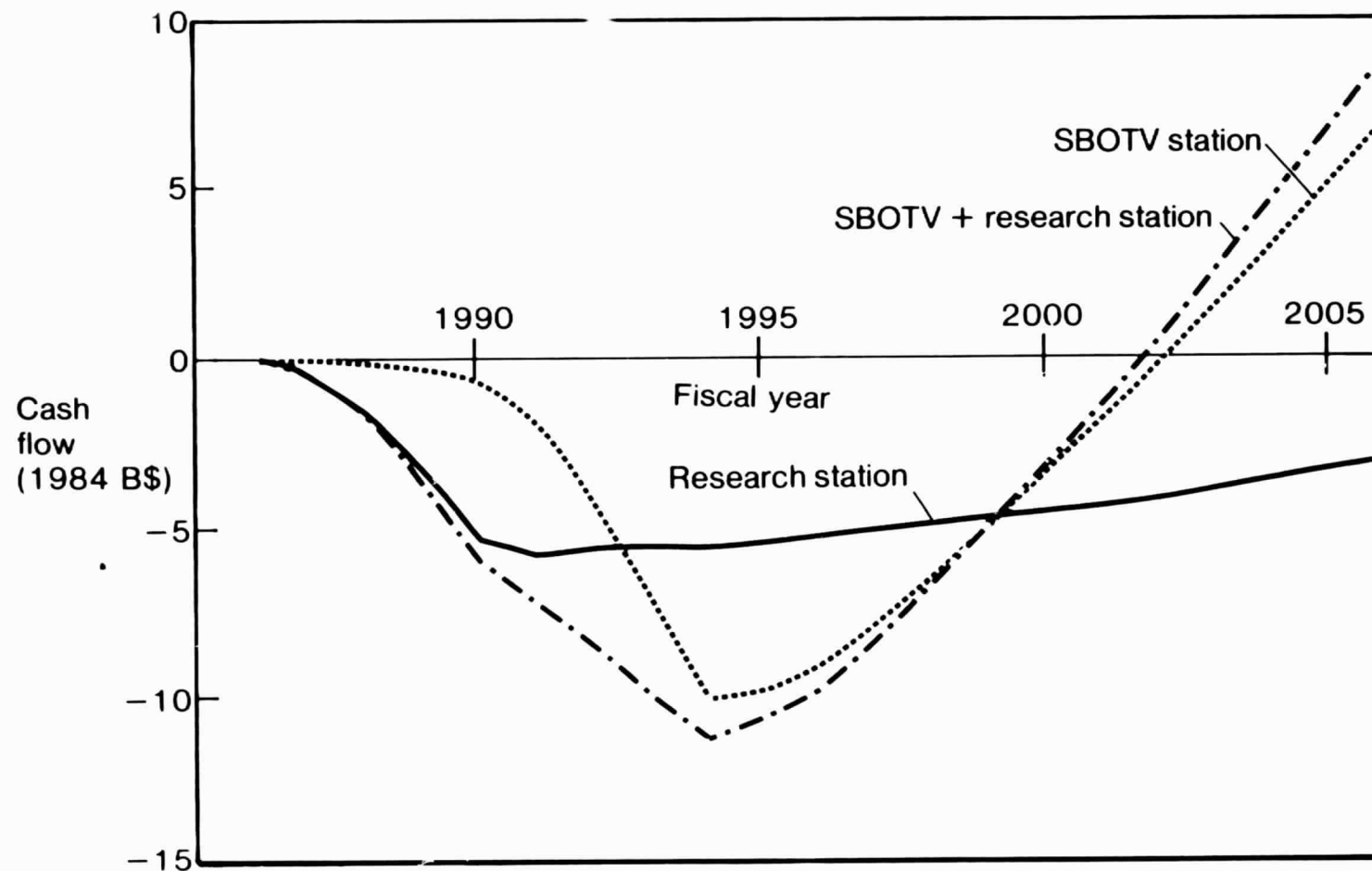
IMPACT OF 5.71 FLIGHTS/YEAR REDUCTION: \$7M COST/FLIGHT INCREASE  
(BUT \$324M ANNUAL REDUCTION IN TOTAL SHUTTLE OPERATIONS COSTS)

## SPACE STATION ECONOMIC BENEFITS (1984 \$)



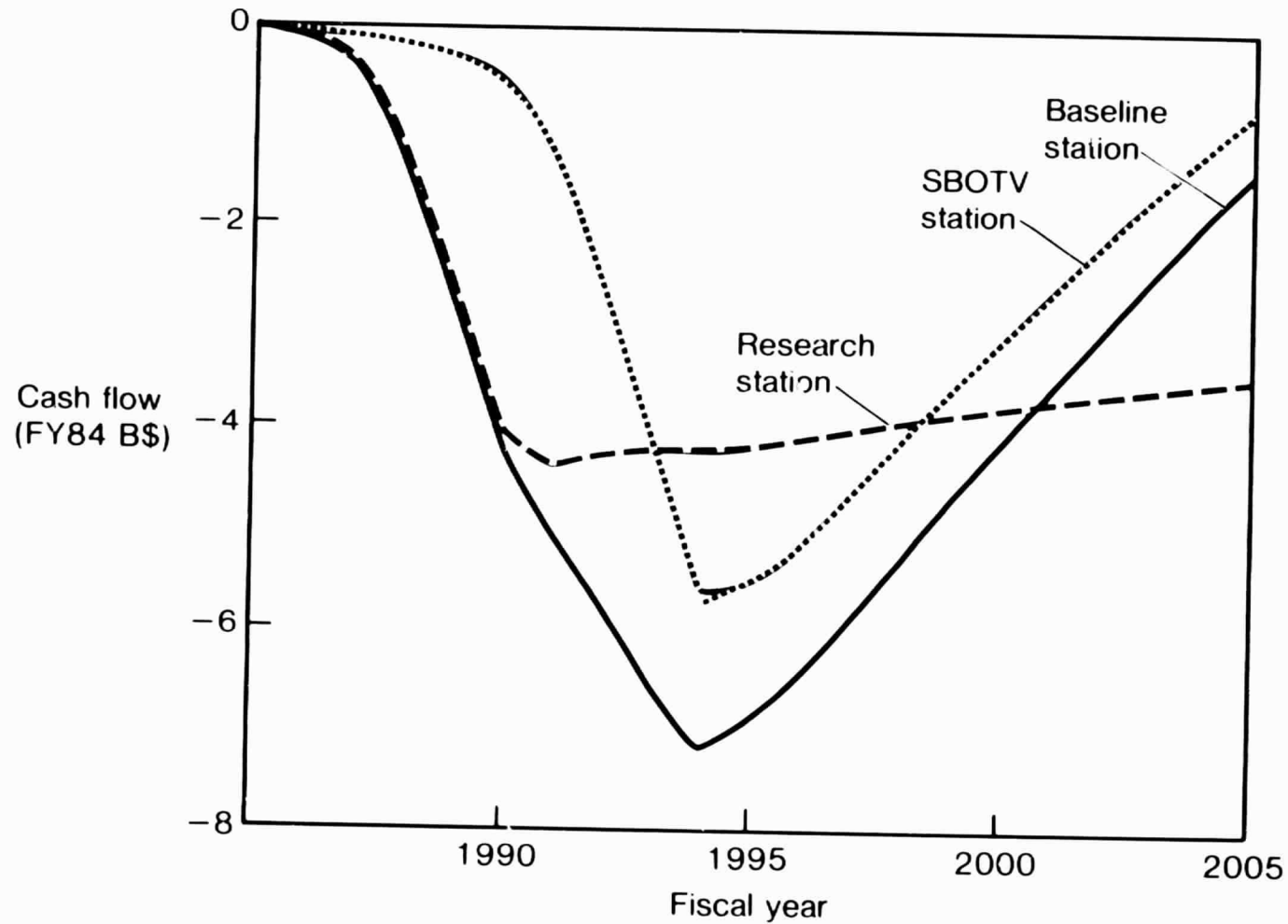
Total economic benefit: \$1.685 billion

## ECONOMIC BENEFITS CASH FLOW Undiscounted

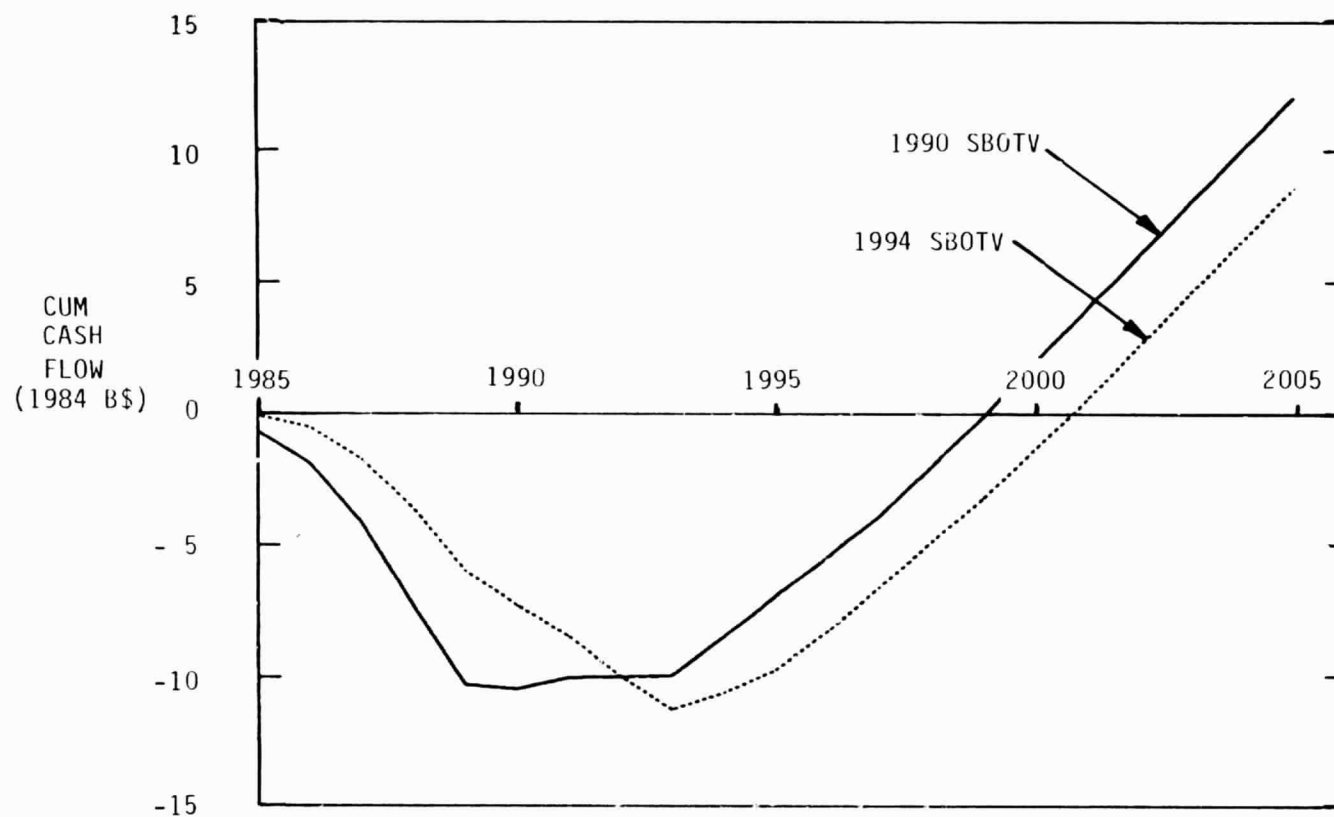


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## ECONOMICS BENEFITS CASH FLOW Discounted (7%)



# ECONOMIC BENEFITS CASH FLOW EARLY SPACE BASED OTV AVAILABILITY



## LCC & PROGRAMMATIC COMPARISONS

### Economic benefits, cost & programmatic analysis (Task 3.3)

- Economic benefits
- LCC & programmatic comparisons
- Programmatic/business opportunity assessment

**Objective:** Provide relative Space Station program ROM costs for the architecture & evolutionary scenario options identified for comparisons & determine implications

**Approach:** Generate alternate program costs with a parametric cost model (element level) & a phased funding model

**Tasks:**

- Mission payload set
- Research station cost
- SBOTV & research station cost
- Annual funding requirements

## **COST ANALYSIS GROUND RULES**

- This study is a requirements & architectural study and not a configuration study
- The economic benefits analysis will be conducted parametrically
- The space station LCC estimates are therefore very ROM & are intended for option comparisons only
- The space station LCC estimates are generated from a parametric model using generic, very ROM input
- Costs are estimated in constant FY84 dollars
- Costs are estimated for the entire space station architecture including government costs
- Annual funding requirements are provided both for specific elements as well as at the total NASA budget level

## SPACE STATION PROGRAM COST ESTIMATES

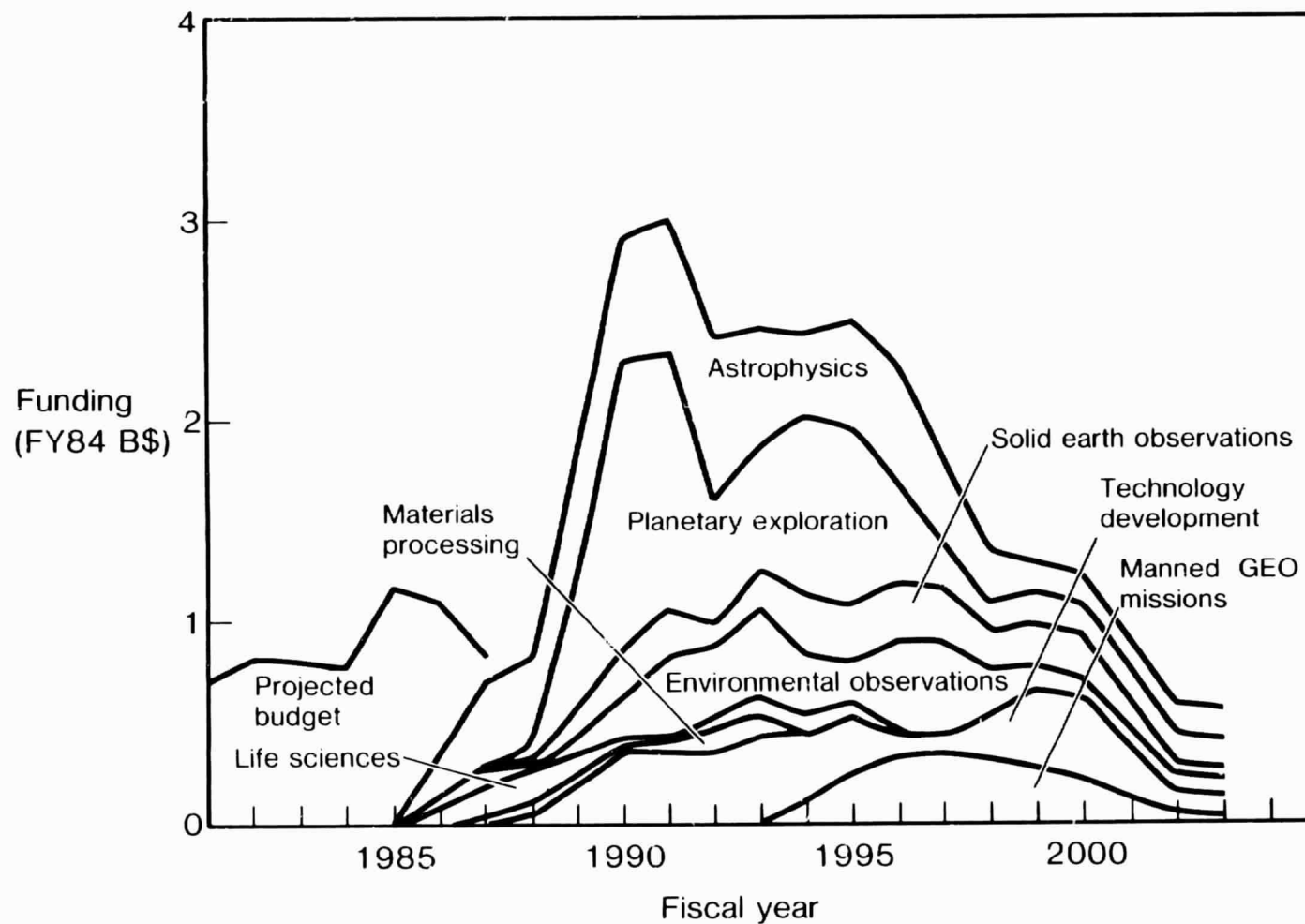
### Approach

- Determine relative program ROM LCC costs for the defined options of:
  - Architecture (hardware)
  - Evolutionary scenarios (programmatic)
- Including:
  - Space stations & mission equipment
  - Free-flyers/platforms & their mission equipment
  - Transportation system
- And use annual funding requirements as a measure of program reasonableness

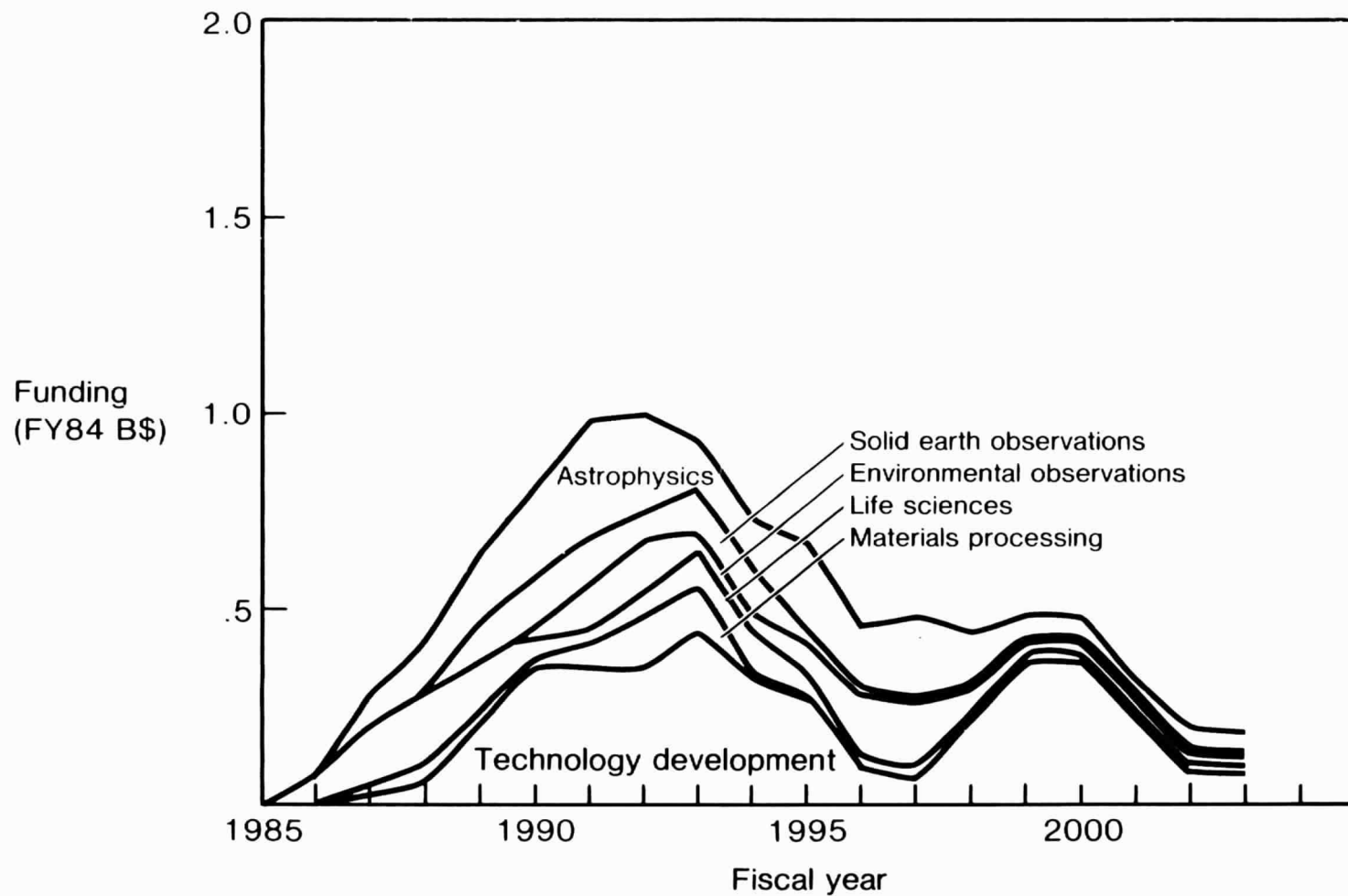
### Methodology

- Use a cost model tailored to the module level to estimate LCC (RDT&E, production & operations) & annual funding requirements
- Calibrate to JSC SOC, Boeing SOC, McDonnell Douglas MSP, etc.

## FUNDING REQUIREMENTS Full Mission Payload Set

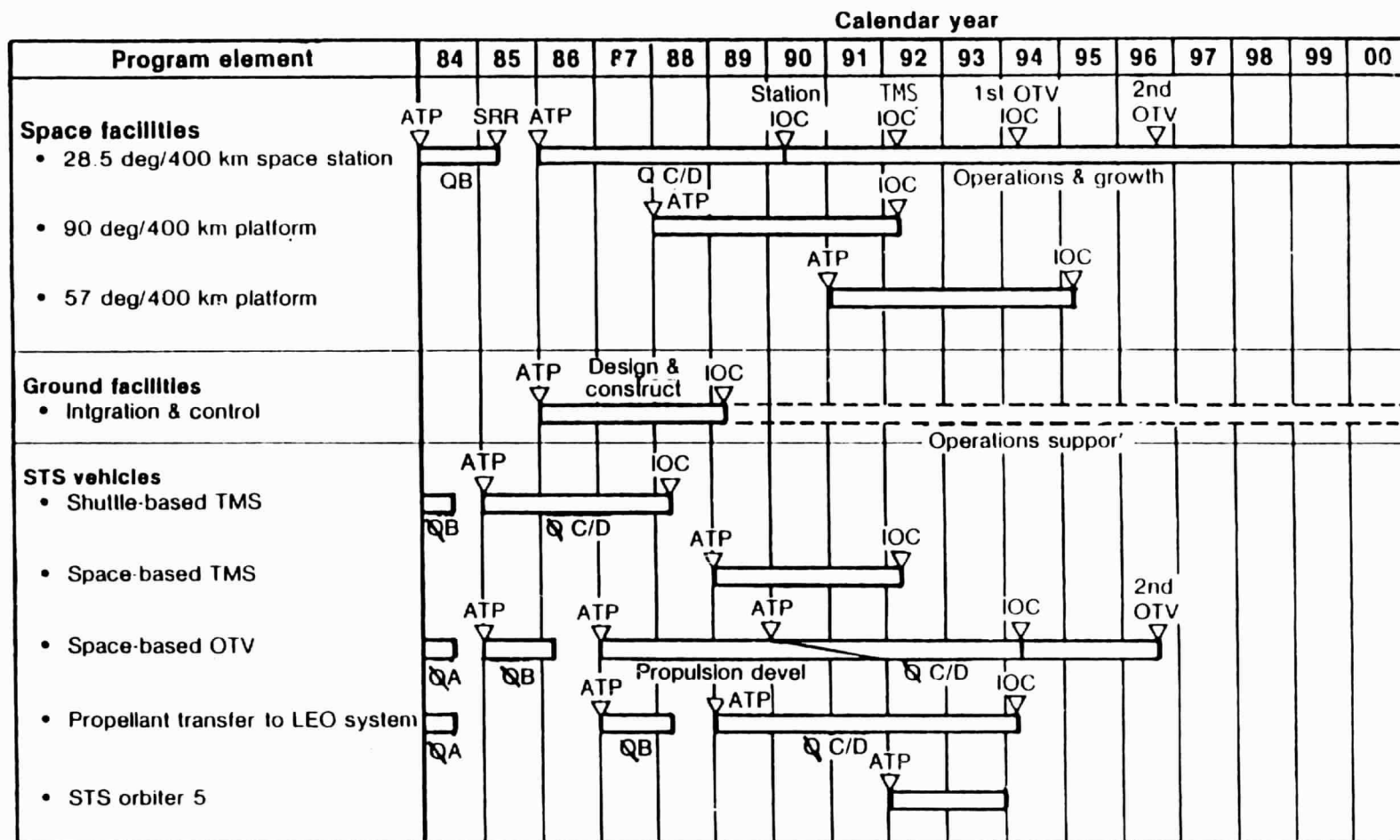


## FUNDING REQUIREMENTS Mission Payload Set (Station-Attached)



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# BASELINE SPACE STATION PROGRAM



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## SPACE STATION MODULE QUANTITY

Module/Item	Research Station	Research Station + SBOTV Operations Station	SBOTV Operations Station	Baseline Combined Research + SBOTV Operations Station
General purpose	1	1		1
Habitability	2	2		2
Mission	5	5		6
Logistics	3	3		6
Passageway	2	2		2
External booms	4	4		4
RMS	1	1		1
General purpose		1	1	
Habitability		1	1	
Mission		1	1	
Logistics		3	3	
Maintenance		2	2	2
Hangar		2	2	2
Propellant storage		4	4	4
Passageway		2	2	2
External booms I		2	2	2
External booms II		2	2	2
RMS		2	2	2

# SPACE STATION PRELIMINARY COST ESTIMATE (1984 M\$)

## MODULE — GENERAL PURPOSE

Cost Element	Size Parameter	Development Cost	Unit Cost
Flight vehicle			
Structure (PRI)	16093.6	159.68	28.32
Structures (SEC)	881.8	13.08	2.08
Tooling		40.48	
Thermal control	28659.8	56.76	38.61
ACS/GN&C avionics	881.8	46.21	13.60
ACS AMCD	5000.0	13.26	2.67
RCS	11023.0	42.17	19.57
EPS solar array	20.0	43.06	26.11
EPS batteries	2.6	4.17	3.04
EPS cond & dist	1543.2	33.44	11.20
Comm/data mgmt	606.3	71.63	12.39
Cont & displays	10361.6	45.78	20.37
EC/LSS	4850.1	212.11	23.31
Crew accommodations	440.9	54.98	1.48
Flight software	200000.0	103.60	
Subtotal		940.41	202.75
IA&CO			24.33
Sustain eng			17.03
SE&I		141.06	
System test		457.66	
Test article		366.71	
Test operations		90.94	
GSE		188.08	
Initial spares		60.83	
Program management		125.16	17.09
Total		1913.21	261.21

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RESEARCH STATION ROM ACQUISITION COST  
(FY 1984 M\$)

GENERAL DYNAMICS  
Convair Division

	<u>DEV</u>	<u>UNIT</u>	<u>QTY</u>	<u>PROD.</u>
GP Module	1913	261	1	261
Habitat Module	619	125	2	250
Mission Module	350	123	5	615
Logistics Module	330	63	3	189
Passageway	280	55	2	110
External Booms	100	10	4	40
RMS	20	10	1	10
Power	-	26	8	208
				<hr/>
TOTAL	3612			1683
GOV'T	903			118
	<hr/>			<hr/>
	4515			1801

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6316

SBOTV OPERATIONS STATION ROM ACQUISITION COST  
(FY 1984 M\$)

GENERAL DYNAMICS  
Convair Division

	<u>DEV</u>	<u>UNIT</u>	<u>QTY</u>	<u>PROD.</u>
GP Module	1913	261	1	261
Habitat Module	619	125	1	125
Mission Module	350	123	1	123
Logistic Module	330	63	3	189
Maintenance Module	345	114	2	228
Hangar Module	248	39	2	78
Propellant Module	595	70	4	280
Passageway	148	60	2	120
External Structure I	151	40	2	80
External Structure II	75	20	2	40
RMS	20	10	2	20
Power	-	26	1	26
	<hr/>			<hr/>
TOTAL	4794			<del>1544</del> 1570
	1199			<del>108</del> 110
	<hr/>			<hr/>
	5993			<del>1652</del> 1680

# RESEARCH STATION & SBOTV OPERATIONS STATION ROM ACQUISITION COST (FY 1984 M\$)

	<u>DEV</u>	<u>UNIT</u>	<u>QTY</u>	<u>PROD</u>
Research Station	4515			1801
SBOTV Operating Station				
GP Module	-	261	1	261
Habitability Module	-	125	1	125
Mission Module	-	123	1	123
Logistics Module	-	63	3	189
Maintenance Module	345	114	2	228
Hangar Module	248	39	2	78
Propellant Module	595	70	4	280
Passageway	148	60	2	120
External Structure I	151	40	2	80
External Structure II	75	20	2	40
RMS	-	10	2	20
Power	-	26	1	26
	<hr/>			<hr/>
TOTAL	1562			1570
GOV'T	391			110
	<hr/>			<hr/>
	1953			1680
Research Station	6463			3481
	<hr/>			<hr/>

RESEARCH & SBOTV OPERATIONS (COMBINED) STATION ROM ACQUISITION COST  
(FY 84 M\$)

	<u>DEV</u>	<u>UNIT</u>	<u>QTY</u>	<u>PROD</u>
GP Module	1913	261	1	261
Habitat Module	619	125	2	250
Mission Module	350	123	6	738
Logistic Module	330	63	6	378
External Booms	100	10	4	40
Maintenance Module	345	114	2	228
Hangar Module	248	39	2	78
Propellant Module	595	70	4	280
Passageway I	280	54	2	108
Passageway II	148	60	2	120
External Structure I	151	40	2	80
External Structure II	75	20	2	40
RMS	20	10	3	30
Power	-	26	8	208
	<hr/>			<hr/>
TOTAL	5174			2839
GOV'T	1294			199
	<hr/>			<hr/>
	6468			3038
	<hr/>			<hr/>

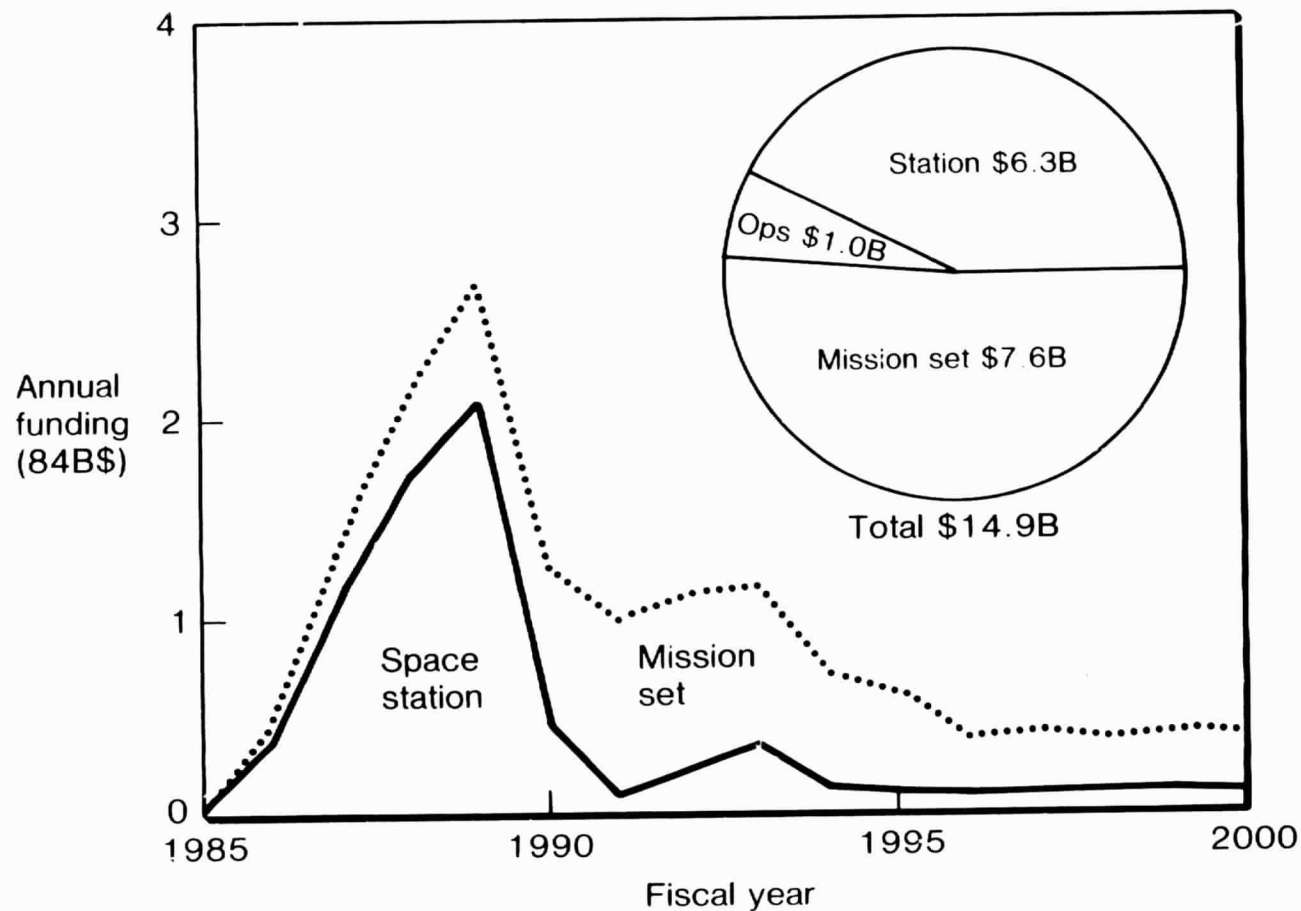
## PRELIMINARY SPACE STATION PROGRAM COST SUMMARY

Case		Cost (FY84 M\$)
A	Research station (to IOC)	5,485
B	Research station	6,316
C	SBOTV operating station	<del>8,140</del> 7,673
D	Research station, then SBOTV operating station	9,949
E	Combined SBOTV operating & research station	9,506

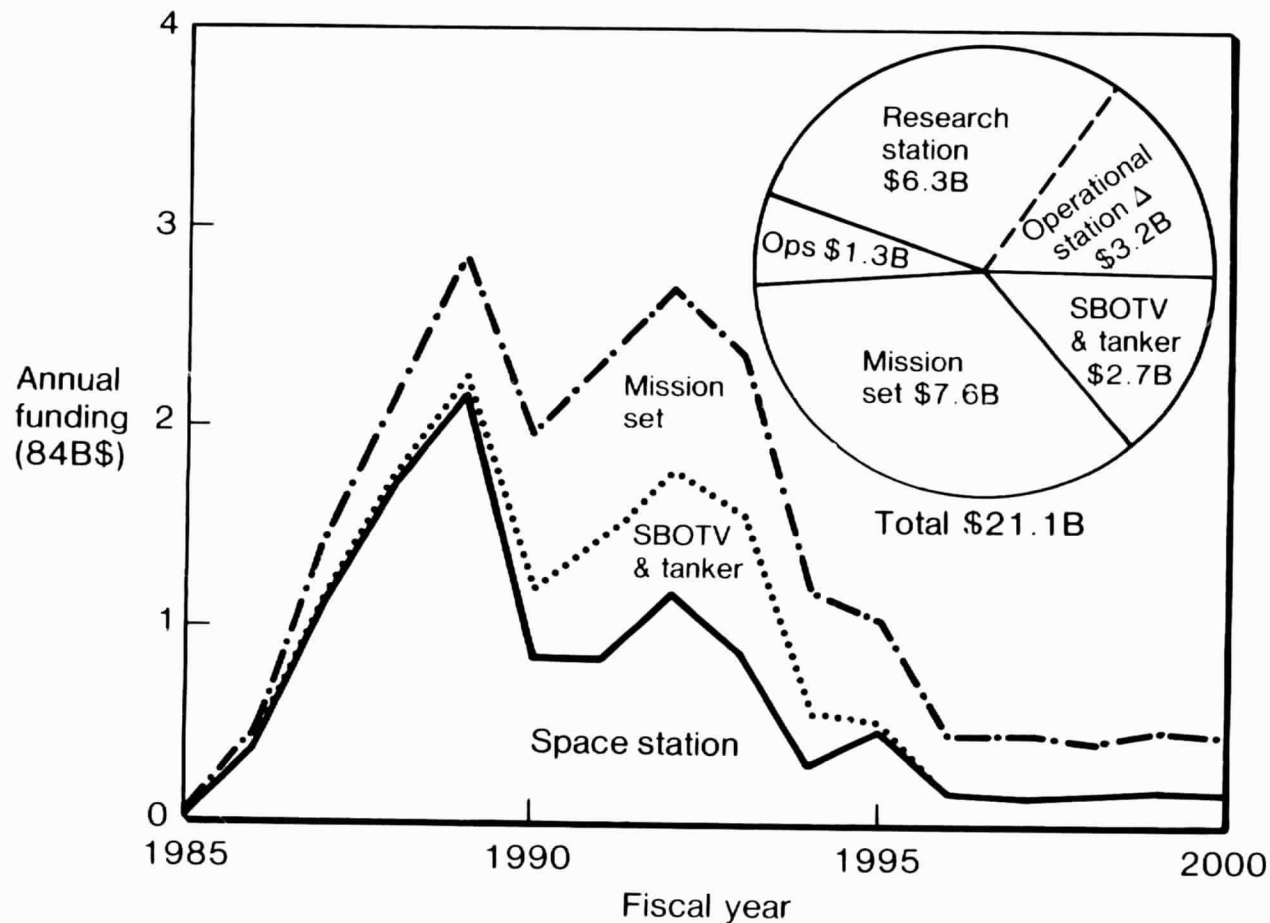
## STS TRAFFIC MODEL Combined Space Station Program

Year	90	91	92	93	94	95	96	97	98	99	00
NASA	10	7	12	14	14	14	13	5	16	6	6
Commercial	11	11	15	12	12	10	8	12	0	7	10
DoD	14	14	12	16	17	13	13	15	20	12	16
Total	35	32	39	42	43	37	34	32	36	25	32

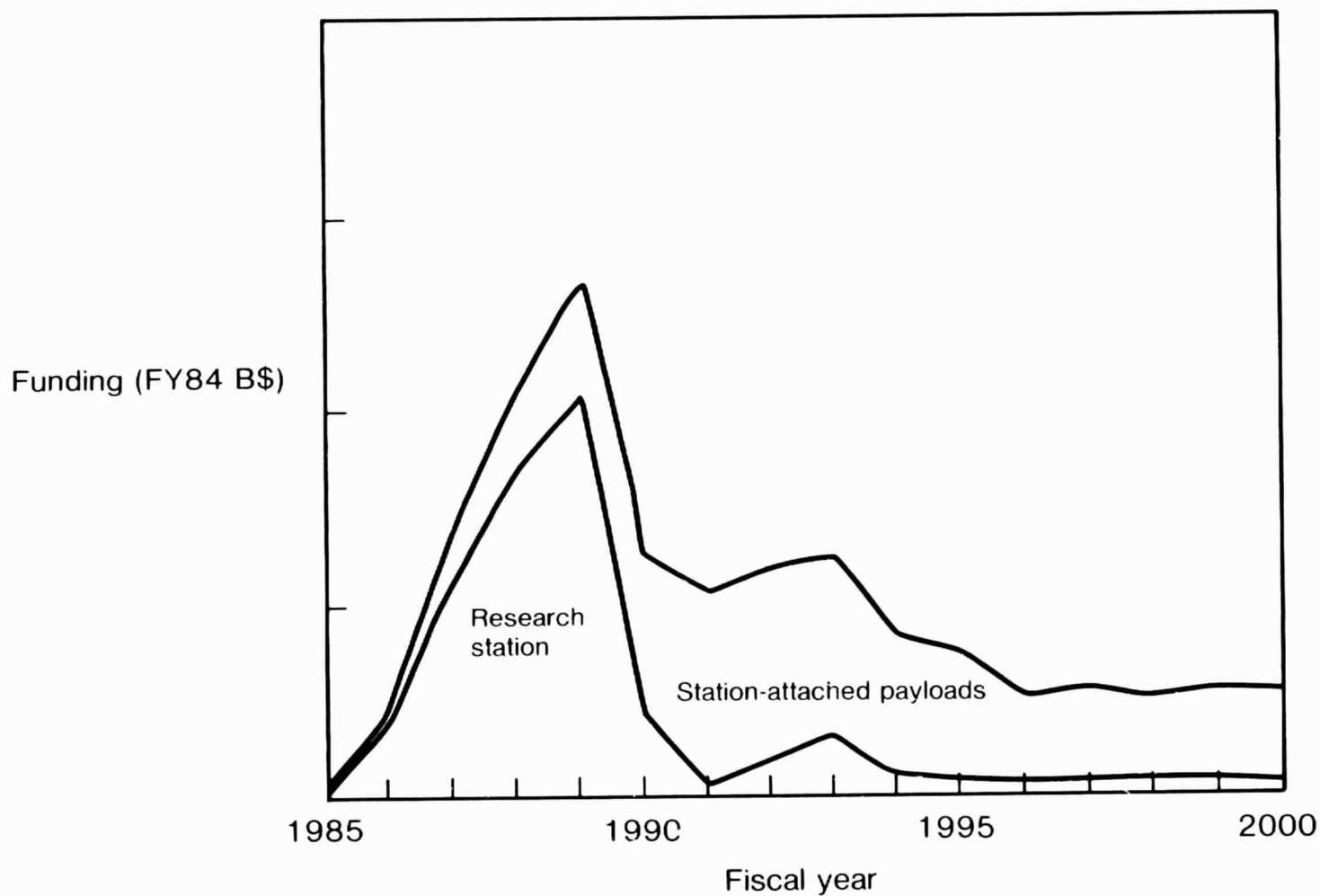
## RESEARCH SPACE STATION PROGRAM FUNDING PROFILE



# COMBINED RESEARCH & OPERATIONS SPACE STATION PROGRAM FUNDING PROFILE

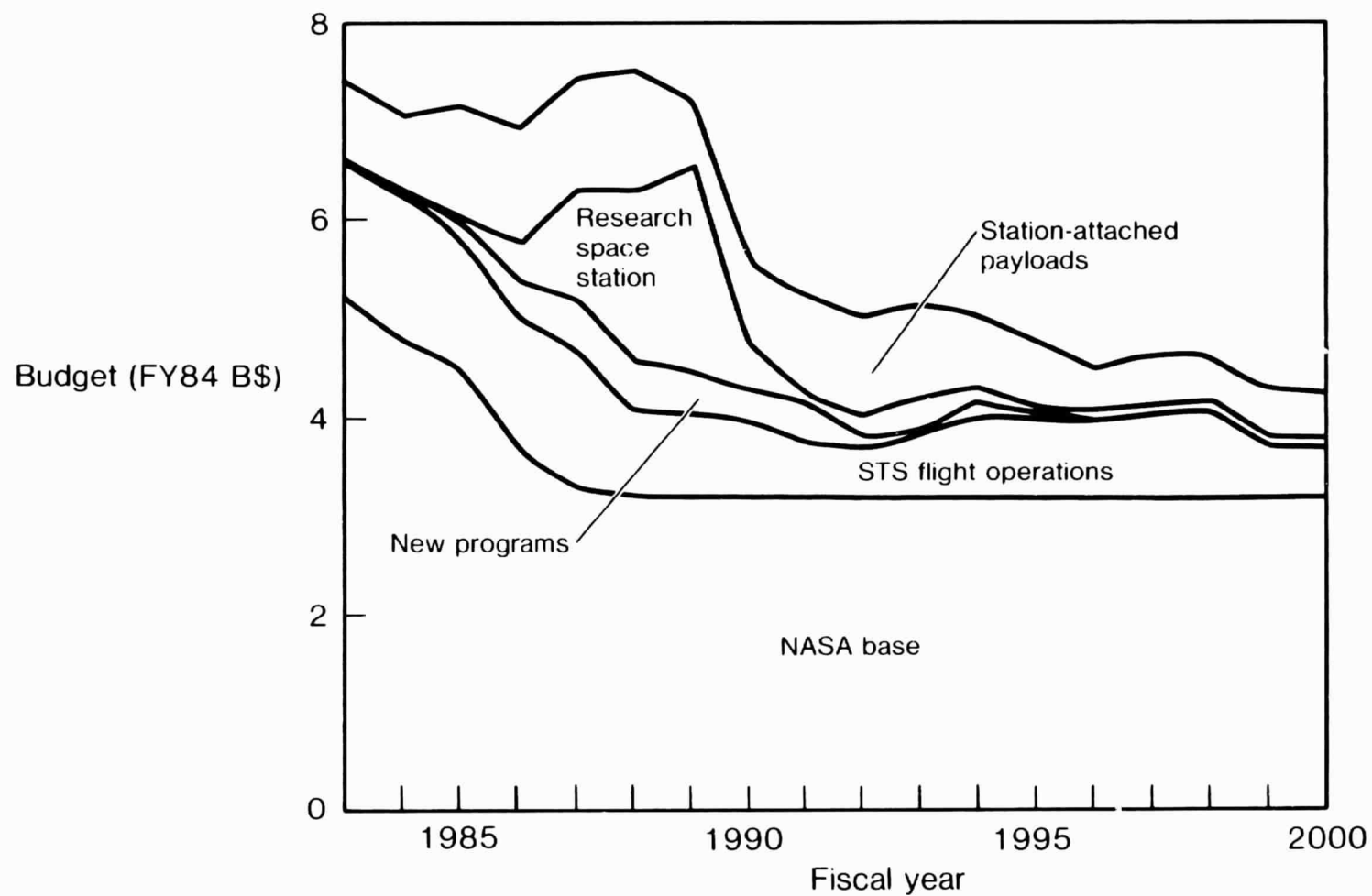


## PROGRAM FUNDING REQUIREMENTS Research Station & Station-Attached Payloads



## NASA BUDGET PROFILE

### Research Station & Station-Attached Payloads

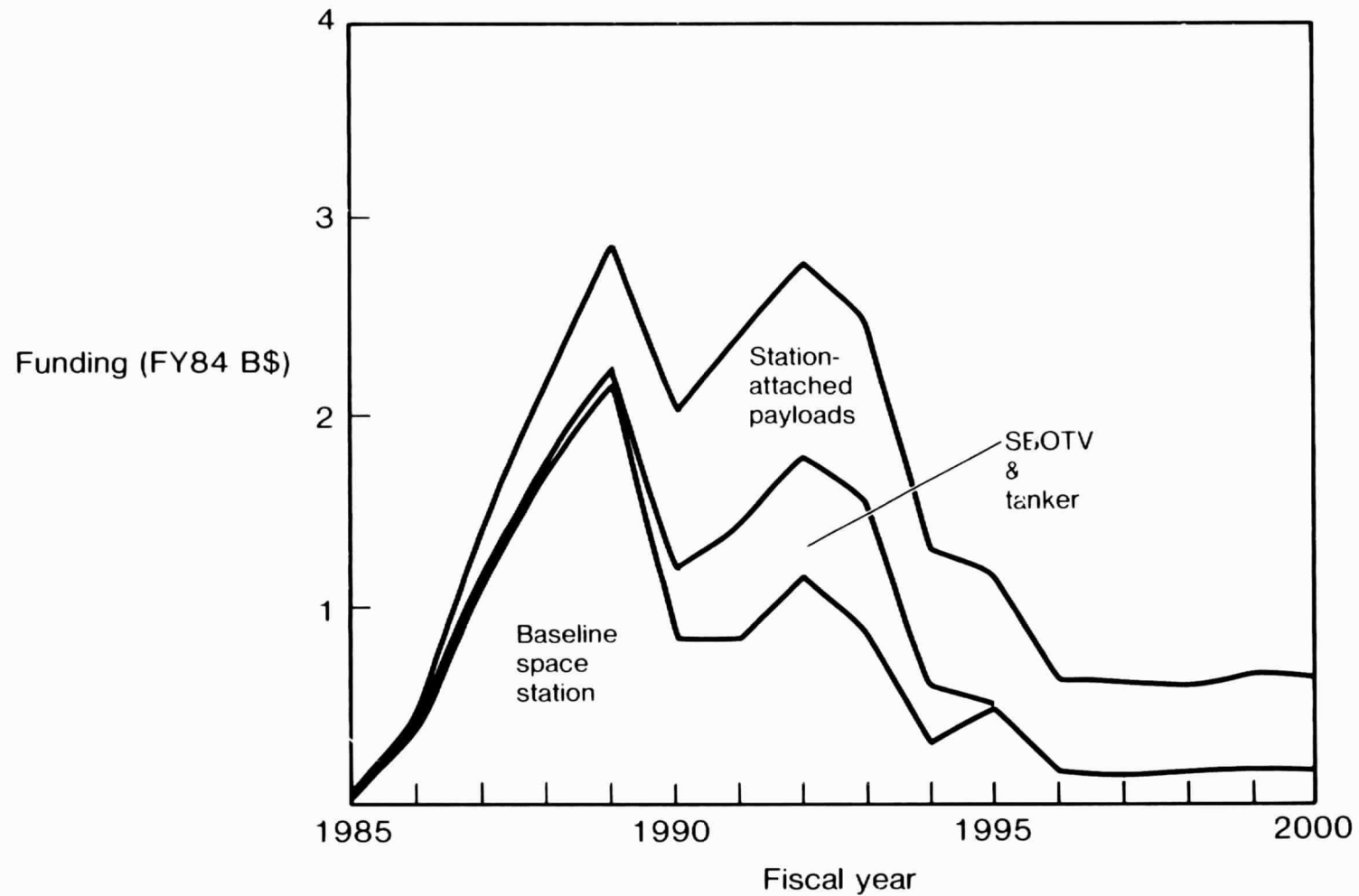


# PROGRAM FUNDING REQUIREMENTS

## Baseline Station & Station-Attached Payloads

### (Combined Research & SBOTV Operations)

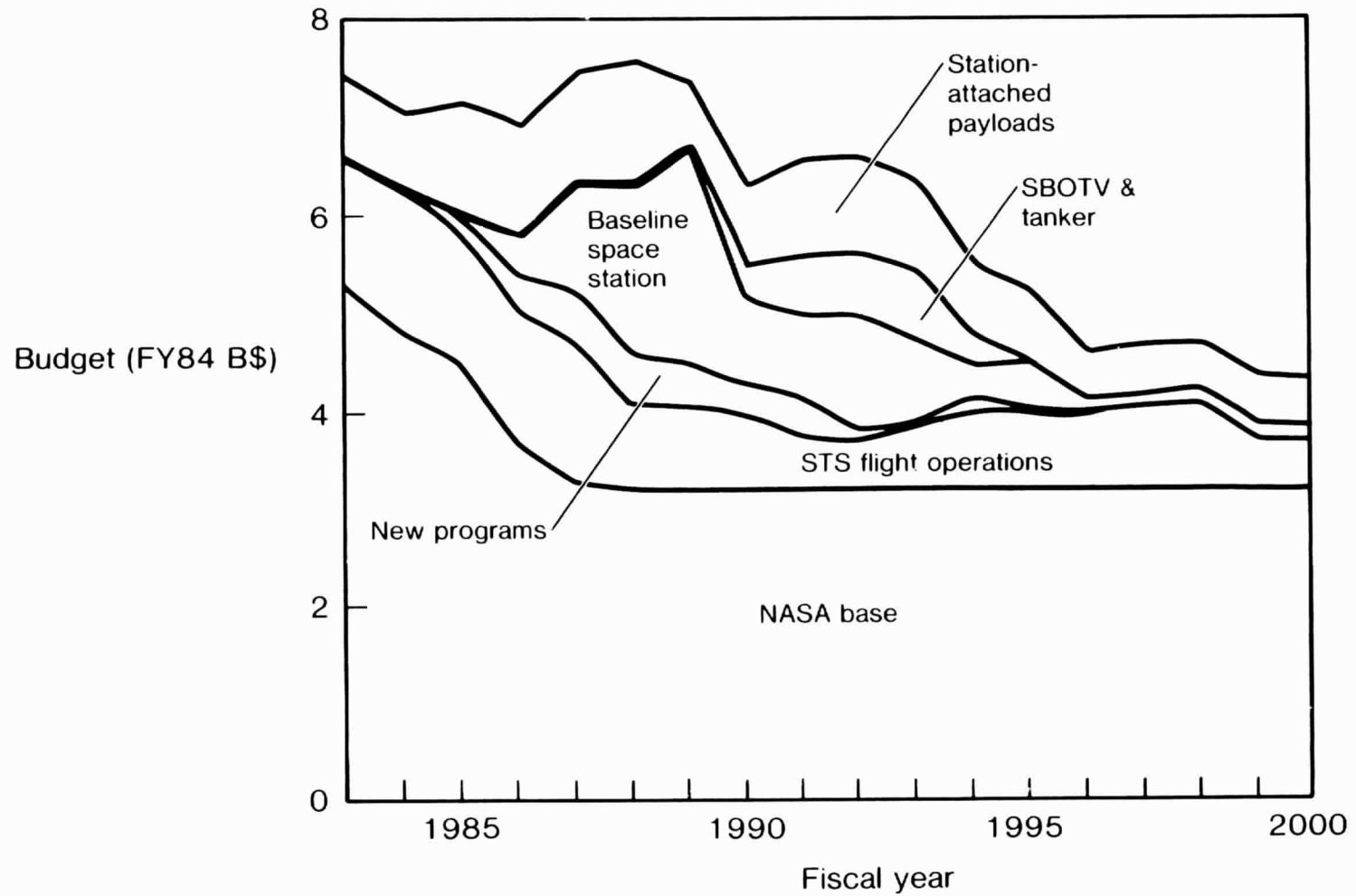
GENERAL DYNAMICS  
Convair Division



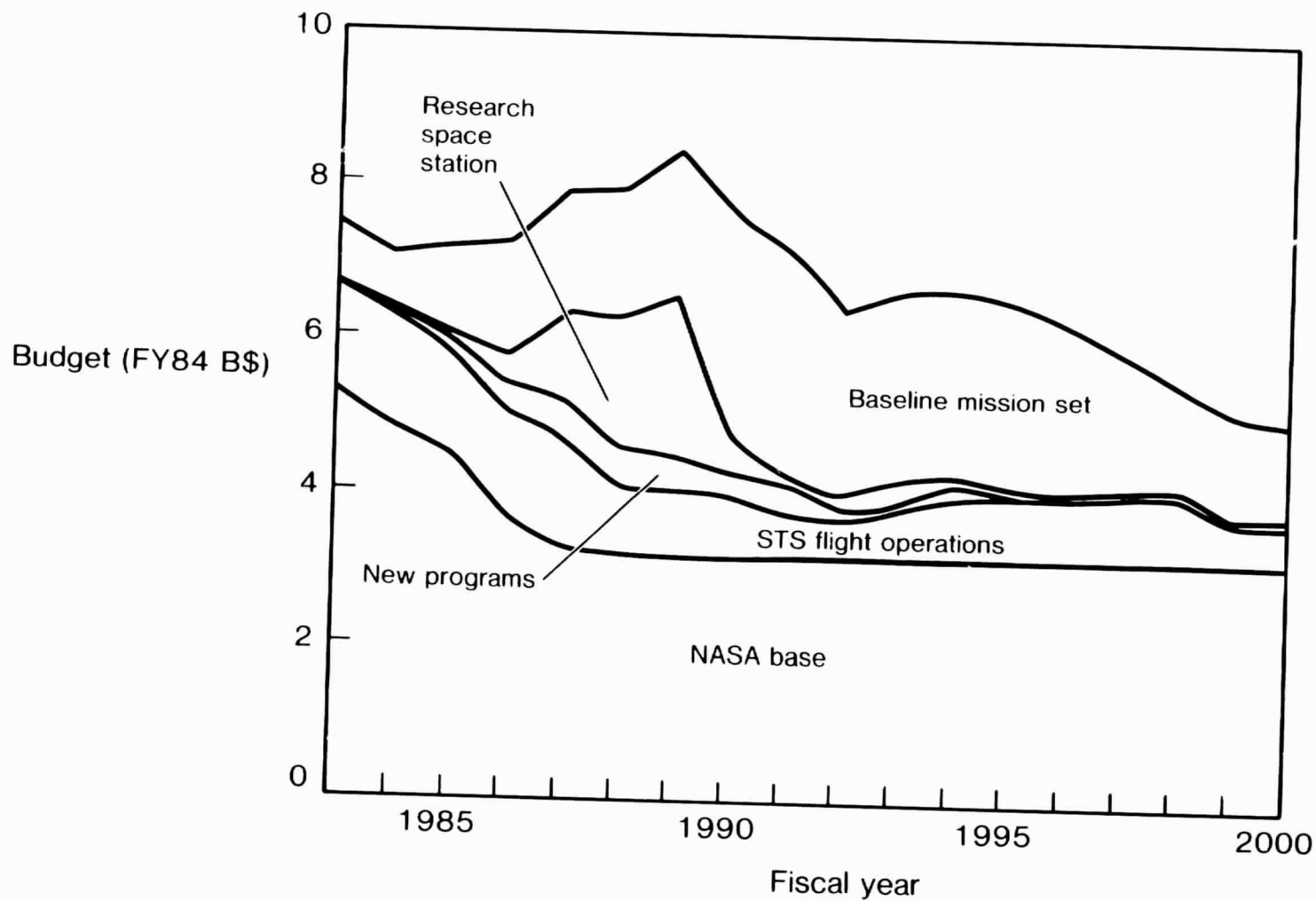
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## NASA BUDGET PROFILE

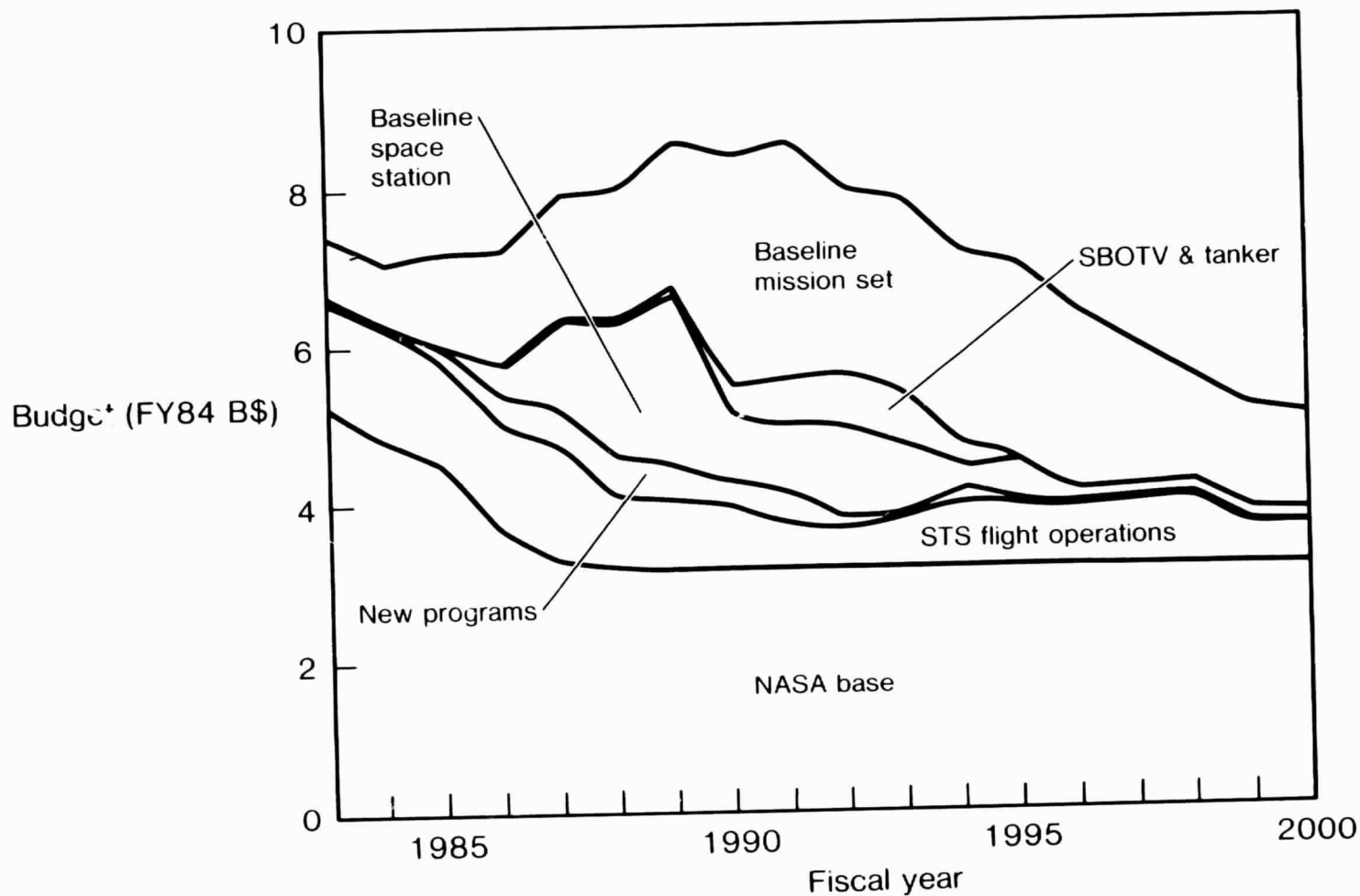
### Baseline Station & Station-Attached Payloads



## NASA BUDGET PROFILE Research Station & Full Mission Set



## NASA BUDGET PROFILE Baseline Station & Full Mission Set



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## PROGRAMMATICS/BUSINESS OPPORTUNITY ASSESSMENT

<b>Economic benefits, cost &amp; programmatic analysis (Task 3.3)</b>
<ul style="list-style-type: none"><li>• Economic benefits</li><li>• LCC &amp; programmatic comparisons</li></ul>
<ul style="list-style-type: none"><li>• Programmatic/business opportunity assessment</li></ul>

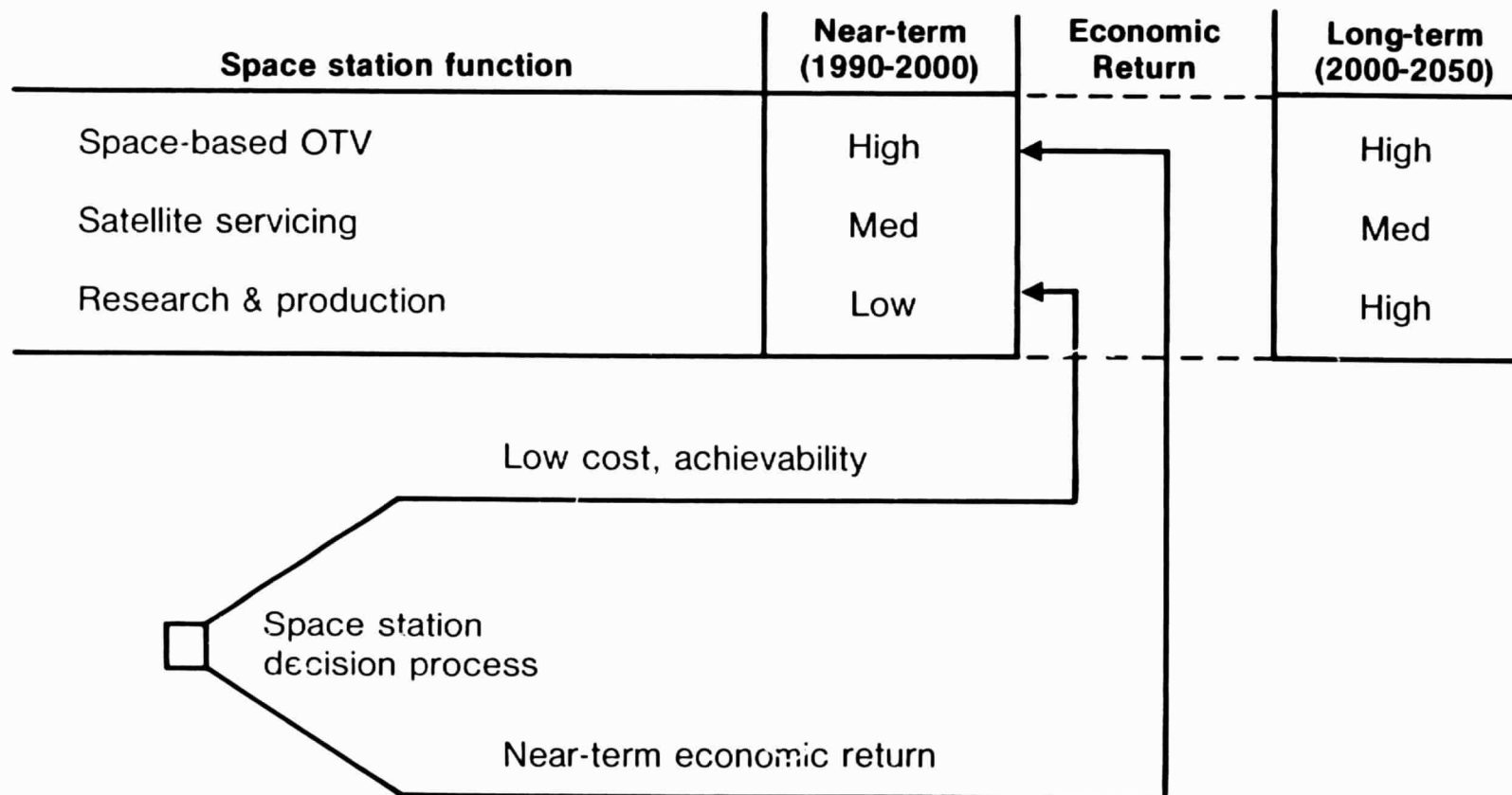
**Objective:** To develop space station program strategies that utilize the capabilities unique to both government & private industry

**Approach:** Identify public & private space station investment criteria, structure joint government-industry programs which meet these considerations, and calculate costs, benefits & risks to program participants

**Tasks:**

- Identify space station marketable elements & systems
- Program definition
  - Space Development Corporation
  - Joint Endeavor Agreements
- Space Station Prospectus

## IMPACT OF ECONOMIC CONSIDERATIONS ON SPACE STATION DECISION PROCESS



# GOVERNMENT INCENTIVES

## Benefits

## Costs

### Financial

Government offers financial incentives to encourage investment in space; e.g., guaranteed loans, tax credits, or cash subsidies.

Highly effective in reducing investment level requirements and financial risk. Costs to government and benefits to industry are relatively simple to quantify.

Often present political problems since financial aid is highly visible and is frequently granted to private sector long before projected returns are evident.

### Logistical

Government offers free or reduced-cost transportation and other services as an inducement to private investment.

Allows government to use its resources to develop systems (e.g., Space Shuttle) over which the government can maintain control and that show a return on taxpayer investment.

Not as effective in stimulating private sector interest as cash assistance and dependent upon government's ability to provide services on schedule for agreed cost.

### Market

Government guarantees or "creates" a market by agreeing to purchase space products or services at an agreed-upon price.

Minimizes risk to government since public resources are not expended until program is completed successfully and final products or services are delivered.

Does not reduce investment level or investment horizon for private investors and usually requires long-term government commitments, often requiring special legislative action.

## GOVERNMENT TASK SHARING

### Benefits

### Costs

#### Developmental

Government performs necessary R&D to demonstrate technical and programmatic concepts; hardware is purchased and assembled privately.

Allows agencies such as NASA to perform basic R&D functions while greatly reducing private sector financial commitments and technical risks.

Can present difficulties in distinguishing "R&D" from "production" and could result in technology development that is not optimized for private sector production and operation.

#### Pre-Operational

Government develops and builds systems and transfers ownership and/or control to private sector after demonstrating operational capabilities.

Greatly reduces all aspects of private sector risk and investment requirements, while giving government greatest control over system development and production.

Entails greatest cost and liability to government, offering none of the advantages of private-sector development or production.

#### Elemental

Government develops and builds core system elements and permits private companies to develop other components to add to main system.

Parallel development can offer the most equitable means of task sharing, also affords government and private sector full control over system development.

Private participants dependent upon government to provide core system elements on schedule; can also create technical and programmatic compatibility problems.

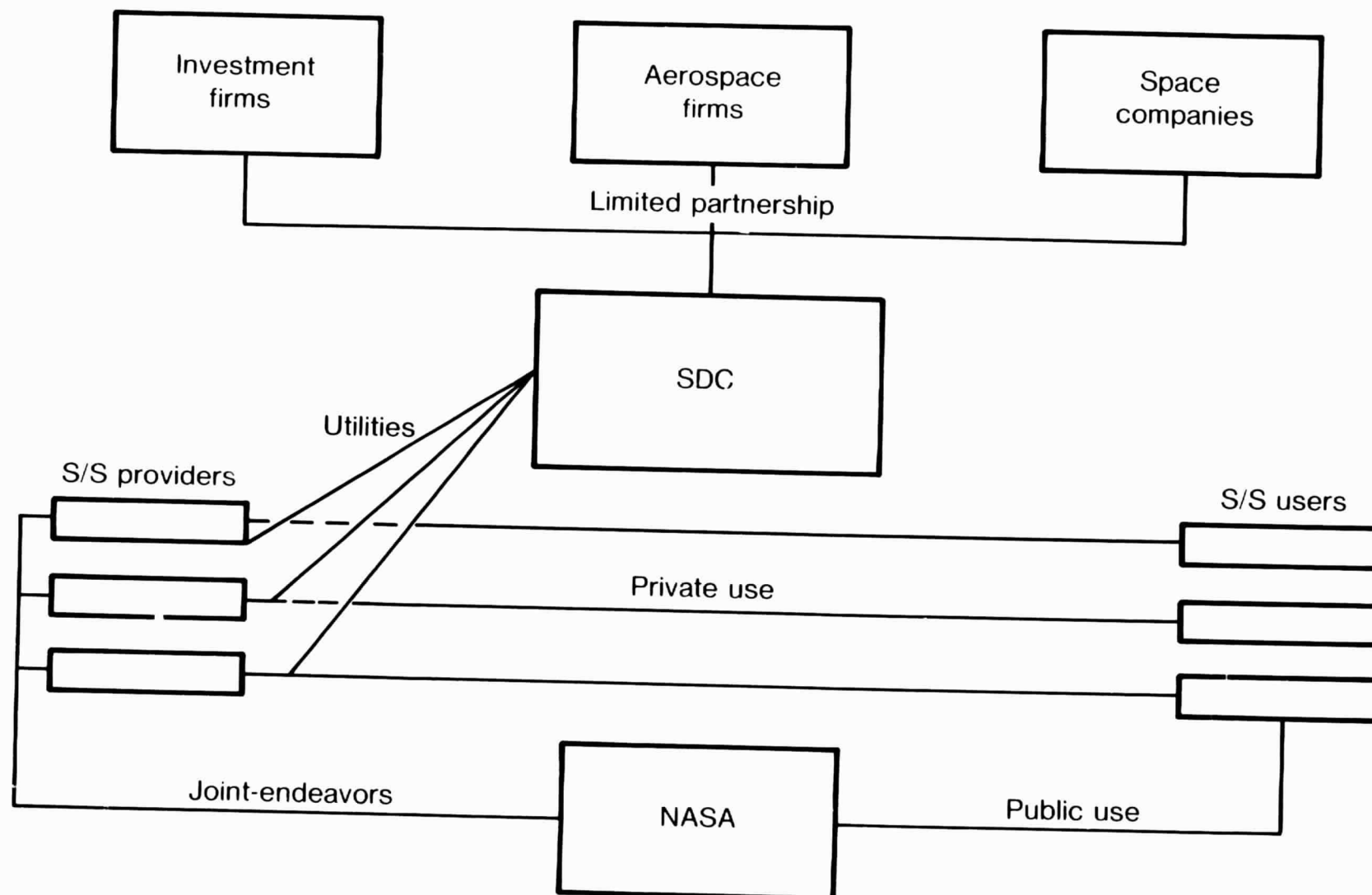
## SPACE STATION PROSPECTUS

- Develops alternate concept for financing a space station program
- Establishes **Consolidated Space Enterprises** as general partner in ten subsidiary space station companies
- Investment in space station companies open to interested firms & general public
- Government investment in \$9 billion space station reduced to approximately \$2 billion
- Seven of ten space station companies appear commercially viable without government financial support
- Net income of space station companies estimated at \$1.87 billion per year on annual sales of \$3.87 billion

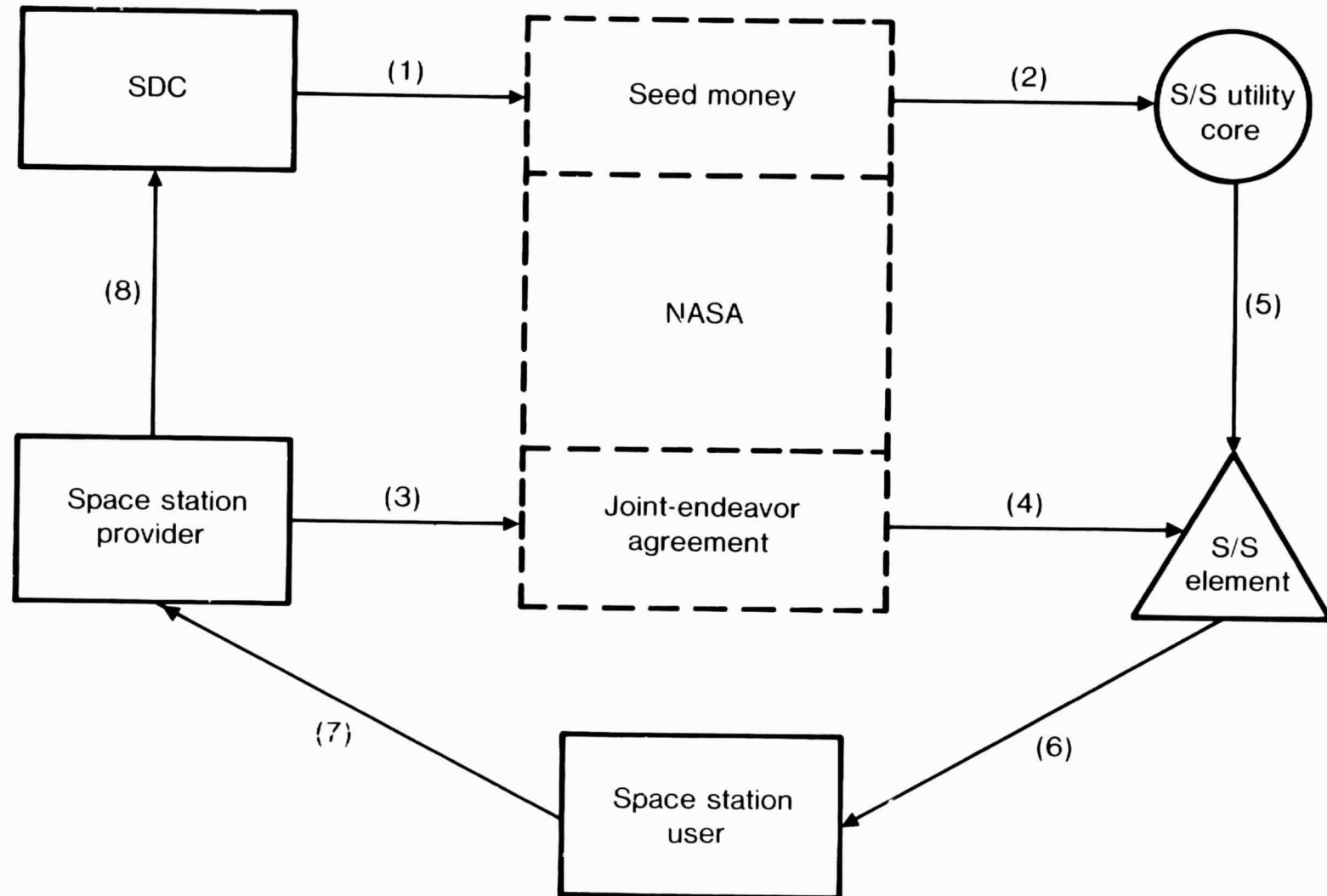
## SPACE STATION FINANCIAL SUMMARY

	Capital Investment	Operating Costs (annual)	Operating Revenue (annual)	Net Income (annual)	Return on Investment (ROI)	ROI Shortfall	Government Requirement	
							Option A = Investment	Option B = Market Guarantee
Space transport company	\$1500M	\$ 750M	\$1400M	\$ 650M	.43	—	0	0
Space repair company	\$ 200M	\$ 280M	\$ 350M	\$ 70M	.35	—	0	0
Space research company	\$1500M	\$ 100M	\$ 300M	\$ 200M	.13	.07	\$ 500M	\$100M
Space products company	\$1000M	\$ 100M	\$ 50M	-\$ 50M	-.05	.25	\$1000M	\$ 250M
Space service company	\$1000M	\$ 200M	\$ 400M	\$ 200M	.20	—	0	0
Space fuel company	\$2000M	\$ 250M	\$ 600M	\$ 400M	.20	—	0	0
Space hotel company	\$1000M	\$ 300M	\$ 600M	\$ 300M	.30	—	0	0
Space power company	\$ 300M	\$ 10M	\$ 100M	\$ 90M	.30	—	0	0
Space phone company	\$ 500M	\$ 10M	\$ 20M	\$ 10M	.02	.18	\$ 450M	\$ 90M
Space systems company	—	—	—	—	—	—	—	—
Total	\$9000M	\$2000M	\$3870M	\$1870M	.21 (avg)	—	\$1950M	\$440M

## SDC ORGANIZATION OPTION



## SPACE STATION: FUNCTIONAL RESPONSIBILITIES



## CONCLUSIONS

- The space-based OTV function offers substantial near-term economic benefits
- The research & production and the satellite servicing functions also offer some near-term economic benefits, great long-term
- The initial recommended research space station cost will be about \$5.5B at IOC & \$6.3B at full capability
- The SBOTV function incremental cost is about \$4.5B. The SBOTV & the propellant tanker will cost about \$2.7B
- The combined space station break-even in terms of economic benefits occurs about 2004
- Several options exist for creating partnership between government & industry in a space station program
- Potentially attractive business opportunities have been identified in the development of several key space station capabilities

## **RECOMMENDED NEAR-TERM ECONOMIC ANALYSES**

- Refine & continue to develop current cost/benefit projections
- Conduct space station & SBOTV operations cost & user charge analyses
- Develop cost modeling for total mission payload set (including free-flyers, etc)
- Identify & estimate funding available from other than NASA users (amount, timing, investment reimbursement, etc)